ENGINEERING

An Illustrated Weekly Journal.

EDITED BY CHARLES COOPER AND J. FOSTER PETREE

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2. TELEPHONE: TEMPLE BAR 3663.

VOL. 176—No. 4575 LONDON: FRIDAY, OCTOBER 2, 1953. Price 8d.

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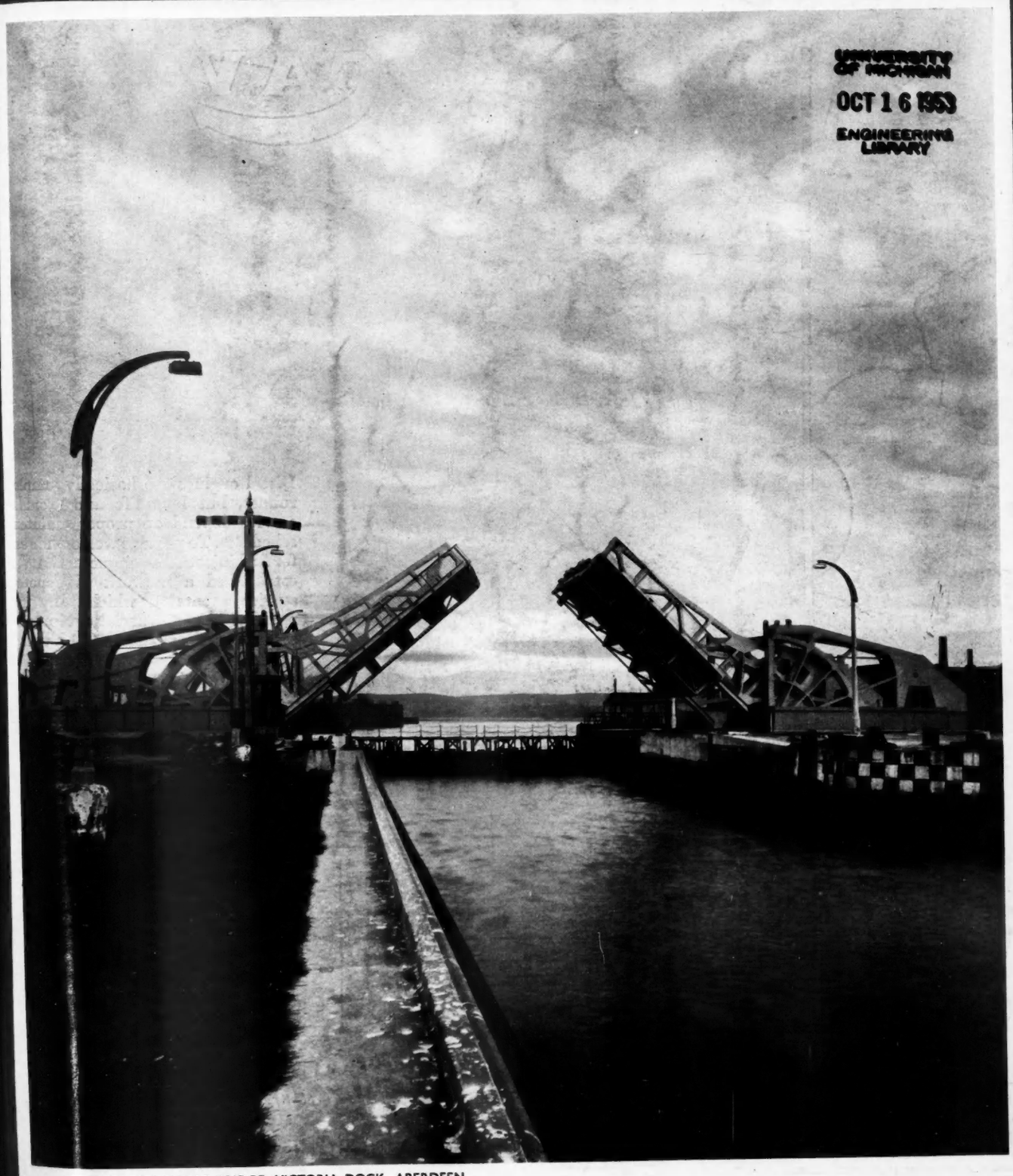

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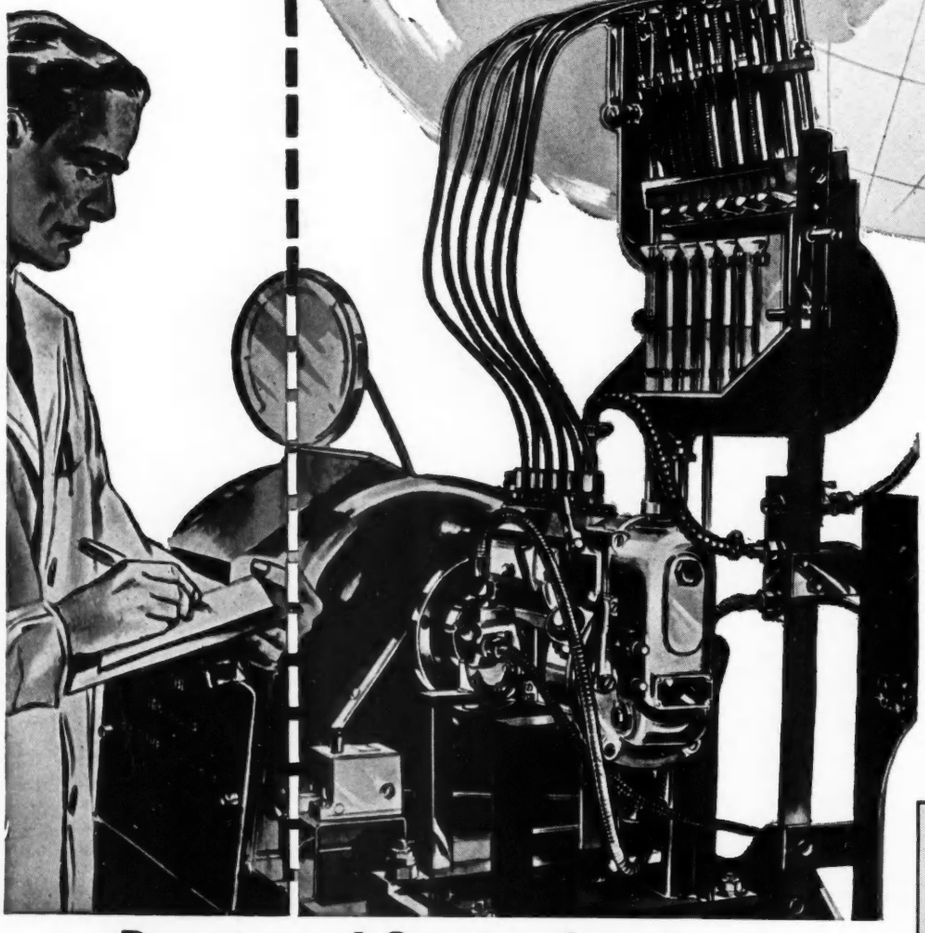

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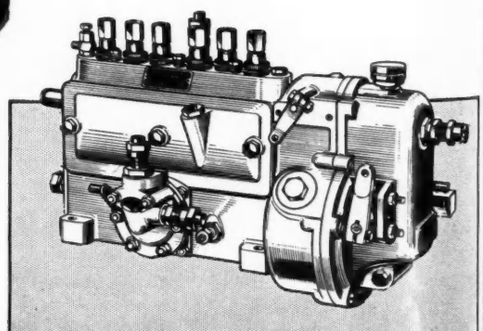

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THE "WELDEX" BLED-STEAM AIR PREHEATER.

THE Weldex marine-type bled-steam air preheater, made by Wellington Tube Works, Limited, Great Bridge, Tipton, Staffordshire, is designed to operate on a principle which is of relatively recent introduction in this country. Similar heaters have, however, been in use in the United States long enough for a considerable amount of data on their performance to be collected. The practical advantages are considerable, as shown by operational experience, and the bled-steam air preheater is coming rapidly to the fore. A detailed examination of air preheating by steam is contained in a paper by Mr. W. J. S. Glass, "Steam Air Heaters for Marine Water Tube Boilers," read before the Institute of Marine Engineers on November 11, 1952. The subject need only be summarised here.

The orthodox flue-gas air preheater used in conjunction with marine water-tube boilers has been a source of trouble in the past for several reasons. Present-day fuels, with a high sulphur content, have aggravated the normal troubles arising from chokage, corrosion, and, occasionally, soot fires, which can cause extensive damage. For these reasons, the costs of maintenance and repair have been high, and, since the bled-steam air preheater has none of the disadvantages of the flue-gas type, it has developed rapidly. As the combustion air is heated by steam, the unit is clean, and there is no possibility of tube chokage. Danger of fire is completely eliminated, and the problem of corrosion is also avoided. The effect of these features on the all-important question of reducing idle time in port is obvious. Further advantages of the bled-steam air preheater are that, compared with the flue-gas type, it is smaller in size for the same duty, and while the flue-gas heater must necessarily be installed in the funnel uptake, the bled-steam heater can be sited in any convenient position in the boiler-room, thus giving greater freedom to the designer in the layout of this part of the ship.

A number of bled-steam air preheaters have been made for ships built, or being built, in this country. The heaters have been designed and constructed by Wellington Tube Works, Limited, for the duties specified by the boilermakers, and are for use in various types of ship, including passenger vessels and oil tankers. The bled-steam air preheaters are supplied for use with steam bled off an intermediate stage of the main turbines when the ship is steaming normally, and with exhaust steam when the main propulsion machinery is shut down. The overall boiler efficiency may be the same as it would be if regenerative flue-gas air preheaters were used instead of the bled-steam type.

An example of a bled-steam air preheater installation in a passenger vessel is provided by that in the 28,000-ton Orient liner Orsova, which was launched at the Naval Yard of Vickers-Armstrongs Limited, Barrow-in-Furness, on May 14. This vessel is equipped with three Foster Wheeler controlled-superheat boilers, the steam pressure being 525 lb. per square inch at the superheater outlet, and three Weldex bled-steam air preheaters giving an air temperature of 210 deg. F. with bled steam at 35 lb. per square inch absolute. Fig. 1 shows one of the Weldex heater batteries about to leave the manufacturers' works. This, of course, is an example of a Weldex installation designed to meet a particular specification, and it should be added that a much closer approach of final air temperature to steam saturation temperature is possible. A temperature difference of 10 to 12½ per cent. can be achieved without difficulty when required; below this figure there are size limitations in the heater unit. The Orsova is still in the fitting-out basin, but the tanker World Enterprise, of 32,500 tons, built by Vickers-Armstrongs Limited at Walker-on-Tyne, and equipped with Weldex heater batteries operating with Foster Wheeler boilers, has been completed, and has undergone successful sea trials.

The design of the Weldex marine-type heater unit is based on the Wellington Tube Works' standard heater battery, which has been in production for land use for a number of years. Modifications to detail have been made to suit the requirements of the marine engineers. Up to the present, no major departure from the standard model has been necessary to make the Weldex unit suitable for particular applications; the design is flexible, and can be adapted in any way to meet possible future needs. The Weldex unit can be arranged for installation with the tubes either vertical or horizontal as required; the former arrangement is perhaps preferable, as it is easier to remove condensate. It is also possible to design units for conversion purposes, since the bled-steam air preheater is both adaptable in design and smaller in size than the flue-gas type. Two such units have been installed in oil tankers, the bled-steam heaters having been designed to fit into the spaces formerly occupied by the flue-gas units.

The basic element of the Weldex heater is the gilled tube, several of which are shown in Fig. 2. The tube is of cold-drawn seamless steel, 1-in. outside diameter, with a wall thickness of 10 s.w.g. (0·128 in.). Fixed on the tube, and spaced at either ¼-in. or $\frac{5}{16}$-in. centres, are the rectangular gills, which are made from 18-s.w.g. (0·048-in) steel; their dimensions are 3 in. by 2 in. The use of flat steel gills ensures that the surfaces exposed to the air flow are smooth, and this, together with the relatively wide spacing, gives freedom from dirt lodgement under normal sea-going conditions. The gilled tube is, however, sufficiently strong to withstand compressed-air or steam-lance cleaning without damage, should it prove necessary. The gills themselves are fixed in position by a unique method, which ensures permanent thermal and mechanical bond. They are placed in special fixtures, the tube is threaded through them, and an expander is then drawn through the tube, which is thus expanded into the gills. Fig. 3 shows a piece of tube from

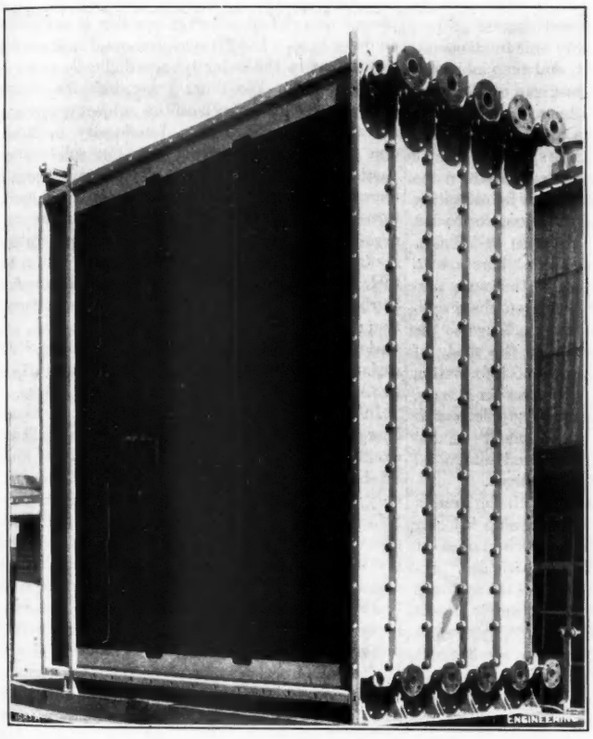


FIG. 1. ONE OF THREE HEATER BATTERIES FOR THE "ORSOVA."

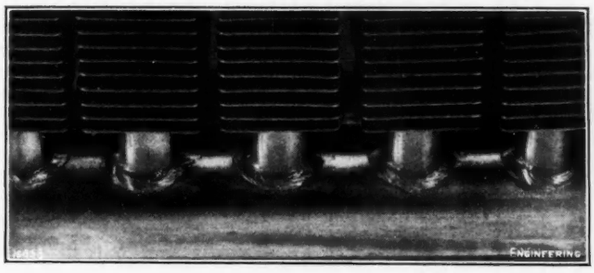


FIG. 2. GILLED TUBES OF HEATER.

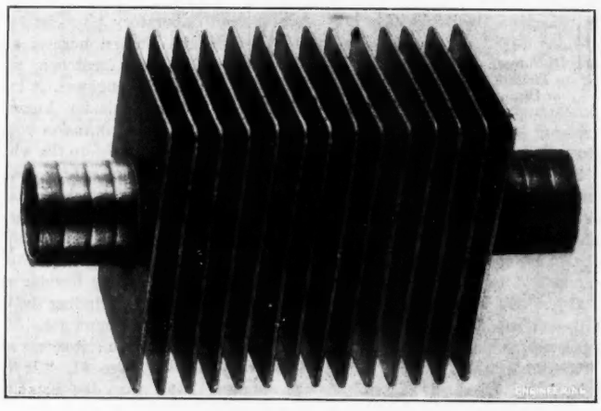
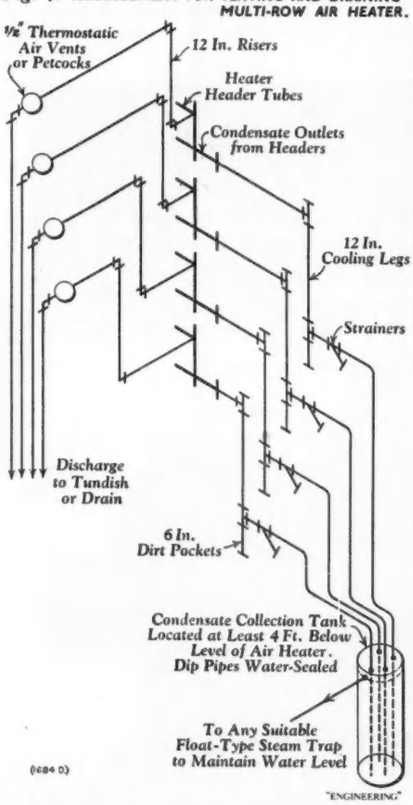


FIG. 3. GILLED TUBE PARTLY STRIPPED TO SHOW METHOD OF FIXING GILLS.

which some of the gills have been stripped; the grooves caused by the expansion of the tube into the gills are clearly visible.

The gilled tubes are assembled into the headers by means of welded joints (Fig. 2) and these sub-assemblies are built up in rows of 10 or 12 into pressed-steel casings of channel section, $\frac{1}{4}$ in. thick. The casings are then bolted together with $\frac{5}{8}$-in. bolts to form the complete unit, as shown in Fig. 1. Asbestos jointing is used between the casing faces. Metering arrangements are incorporated in the design to ensure even distribution of steam to each tube. The heater battery has to be provided with means for disposing of air and condensate, and suitable connections are incorporated for this purpose. The recommended arrangement is that the heater should be split into sections for steam trapping and air venting, and that separate manual or automatic air vents should be provided. A typical trapping and venting arrangement is shown diagrammatically in Fig. 4, but the system is variable, and is decided to suit the particular application. In Fig. 4, the sections are individually vented and there is a common sealing tank together with a single steam trap. An alternative arrangement (which, like that shown in Fig. 4, is for heaters with vertical air flow) provides for individual trapping, but is otherwise similar.

Fig. 4. ARRANGEMENT FOR VENTING AND DRAINING MULTI-ROW AIR HEATER.


½" Thermostatic Air Vents or Petcocks
12 In. Risers
Heater Header Tubes
Condensate Outlets from Headers
12 In. Cooling Legs
Strainers
Discharge to Tundish or Drain
6 In. Dirt Pockets
Condensate Collection Tank Located at Least 4 Ft. Below Level of Air Heater. Dip Pipes Water-Sealed
To Any Suitable Float-Type Steam Trap to Maintain Water Level
"ENGINEERING"

Maintenance and inspection of the tubes can be carried out in the case of the normal heater battery by dismantling the unit section by section. An alternative design is available in which the whole battery is contained in a single casing, with the gilled sections individually removable for inspection.

Speech Diaphragms for Oxygen Masks.—Oxygen and air masks of the demand type, made by the Mine Safety Appliances Company, Pittsburgh, 8, Pa., U.S.A., are being fitted with speech diaphragms to reduce the danger of errors due to misunderstandings. It is claimed that the Saran diaphragm transmits speech without distortion and is impervious to heat, acid or corrosive fumes. Telephonic equipment can be used in conjunction with these diaphragms.

LITERATURE.

Flames, Their Structure, Radiation and Temperature. By Dr. A. G. Gaydon, F.R.S., and Dr. H. G. Wolfhard. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 55*s*.]

Flames can be classified physically according to the way in which the oxygen reaches the fuel. Clearly, the instantaneous chemical processes at any point near a solid fuel particle, or in the vapour from a liquid droplet, can be closely similar to those which occur steadily at a fixed point in space in a laminar diffusion gas flame or in a laminar premix flame, according to the previous history. For this reason, Dr. Gaydon and Dr. Wolfhard justifiably concentrate their research and the subject matter of their book largely upon the laminar premix and diffusion flames. When the Bunsen burner is fully understood under all temperature and pressure conditions, and with all fuels and degrees of premixing, they argue that not only will fundamental knowledge be greatly extended, and that more will be known about how to engineer gas cookers and geysers, but also that it will be a great help to the engineering of water-tube boilers and open-hearth furnaces. In fact, the spatially simple conditions of the non-turbulent steady state flame provide the most promising method of investigating the fundamental processes of diffusion, formation and decay of active species, excitation and ionisation, and soot formation, and the authors are to be congratulated on presenting a thorough and timely survey of present knowledge on these subjects. Their book thus provides a challenge to the laboratory physicist to proceed with the study of the Bunsen burner, and a source of information on the microscopic physical processes in flames. For the engineer, it is necessary to supplement it with particular knowledge of turbulent mixing processes, diffusion round particles and integrated radiation before the whole picture emerges.

Chapters II to V deal essentially with the premix flame, for which the concept of a burning velocity provides a simple connection between flames of different shapes. Chapter IV, in particular, provides a very useful critical review of all the methods of measuring burning velocity; the simple nozzle method, excluding the base of the flame, appears to give the most reliable results. One small point of criticism: it seems a pity to say, in a text-book, as on page 51, "It can be shown (Damköhler, 1940) that the pressure differences between . . . initial unburnt gas . . . and . . . final . . . burnt gases . . ." when the formula given could be derived from momentum conservation in a few lines. Chapter V deals with the various theories as to how flame is propagated in the premixed gases. Experiment indicates that there is a thin preheating zone ahead of the flame in which the unburnt gases are heated up primarily by conduction; the actual temperature at which they ignite is not, however, equal to the self-ignition temperature observed in experiments in which much longer times are available. Two main types of theories are put forward as to what decides the point at which reaction starts, namely, the thermal theory that a temperature must be reached dependent upon the final temperature and an activation energy, and the diffusion theory that the reaction depends on back diffusion of active free radicals. Evidence for the two theories is at present only indirect, and only microscopic observations of the temperature course and reaction course in the flame front can give direct knowledge. Turbulence only increases the flame velocity by a factor of the order of 2 while the flame itself increases the turbulence, but no satisfactory theory of the effect of turbulence exists.

Diffusion flames (Chapter VI) have no fundamental property corresponding to burning velocity, and the chemical reaction is not the rate-determining process; the bringing together of air and fuel by molecular or turbulent diffusion is certainly the main factor. For this reason, the height of laminar flames is proportional to the velocity for a given nozzle size, while that of turbulent ones is nearly independent of the velocity. One of the authors has been concerned in the development of a flat-flame diffusion burner in which the structure of the reaction zone can be studied spectroscopically. By measuring the temperature (Na-line reversal) and the O_2 and OH concentrations, it can be shown that there is chemical equilibrium in the flame. In an ethylene flame, the carbon luminosity arises from a region where the fuel is decomposed thermally in the absence of oxygen.

Chapter VII describes flames which vibrate, a phenomenon which is connected with rough noisy combustion in gas-turbine combustion chambers. Sensitivity to sound in diffusion flames is a property of the gas jet, and is not due to combustion. Both premix and diffusion flames can sing if enclosed in an outer tube. Lord Rayleigh showed that pressure oscillations in the outer tube periodically interrupt the flow from the inner tube, but the authors conclude that more work on this subject is necessary for a full understanding. Luminosity in flames, due to the formation of radiating solid carbon particles (Chapter VIII), may be advantageous in increasing flame emissivity as in the open-hearth furnace, or disadvantageous because of the time necessary to burn the particles in the gas turbine. Sooting increases with increasing C/H ratio in the fuel, and with increased branching in paraffins. Turbulence in diffusion flames reduces soot formation; high pressure favours soot formation, and various additives work in either direction. The carbon particles are graphitic and 0·01 to 0·05μ in size, and they are formed basically by pyrolysis.

In the next chapter it is shown that, in flames, energy flows one way from collisions into radiating excitation, so that the radiant temperature could be below the collision temperature. This effect only occurs appreciably, however, at pressures below a tenth of an atmosphere. The opposite effect of chemiluminescence, in which the chemical reaction produces excitation directly, also occurs in certain flames even at atmospheric pressure. Chapters X and XI deal with the measurement of flame temperature by the spectral line reversal method and other methods, and Chapter XII with the detailed calculation of flame temperature, allowing for the actual equilibria of all the reactions. The method given in this chapter is the one on which all others must be based and illustrates the principles, but for practical use it is necessary to use charts or tables constructed from it. The chapter on ionisation in flames is particularly useful, as it shows clearly how the conductivity of flames, with and without alkali metals, can be explained as a chemical equilibrium between neutral atoms, electrons and charged atoms. The last two chapters pose a number of unsolved problems.

The book will be invaluable to anyone who wishes to do research in flames, as all the evidence and the different theories are carefully and fully reviewed. The practical man may sigh for more clear-cut answers to the questions formulated, and the working hypotheses, but Dr. Gaydon and Dr. Wolfhard, as true scientists, prefer to admit ignorance rather than give unfounded *ex cathedra* statements.

The Institute of Marine Engineers.—The next examinations for the admission of students to the Institute of Marine Engineers will be held from April 6 to 9 and from October 5 to 8, 1954. This is the Common Preliminary Examination. The examination for graduates, i.e., Sections A and B of the associate-membership examination, will be held from April 26 until May 19, 1954. The examination for associate-membership will be held from April 26 to May 20, 1954. Syllabuses, and particulars of exempting qualifications, may be obtained from the Institute, 85, Minories, London, E.C.3.

PERFORMANCE OF A TWO-STROKE OIL ENGINE FOR AUTOMOBILES.

By PROFESSOR S. J. DAVIES.

(*Concluded from page* 387.)

THE data given in the tests were first plotted as specific consumption, in lb. per brake horse-power per hour, on a base of mean-effective pressure. The curves are shown in Fig. 4, and, from these, some interesting conclusions may be drawn. At all speeds, brake mean-effective pressures of 60 lb. per square inch and over were reached, which, of course, correspond to 120 lb. per square inch and over in a four-stroke engine. At speeds up to 2,000 r.p.m., the best consumptions were at or below 0·46 lb. per brake horse-power per hour. If the consumptions at a brake mean-effective pressure of 60 lb. per square inch are considered, these fall at or below 0·49 lb. per brake horse-power per hour for all speeds up to 2,400 r.p.m., and, at the top speed of 2,800 r.p.m., reach only 0·54 lb. per brake horse-power per hour. Bearing in mind the small cylinder diameter and the high speeds of revolution, these results must be considered as very satisfactory. The slopes of the curves, as the brake mean-effective pressures are reduced, show that the specific consumptions at reduced loads do not increase very rapidly. It is this fact, in particular, which, in transport service, gives such an advantage to the oil engine when compared with the petrol engine.

Attention may be directed to the encircled points near the ends of the curves. These give the values for each series at which the "limit of satisfactory exhaust" was reached. The state of the exhaust was observed throughout, but in order to obtain these values, especially careful tests with gradually increasing torques were carried out, so that the transition from a clear to a visible exhaust could be observed with accuracy.

The engine ran smoothly and without excessive combustion noise under all conditions. From the mechanical point of view, in the absence of all valves, noise was negligible.

An alternative method of plotting the data from these tests is shown in Fig. 5, in which the ordinates give values of brake mean-effective pressure and the output torque, and the base is revolutions per minute. The full-line curves are lines of constant specific fuel consumption, the broken curves are lines of constant brake horse-power, while the single chain-dotted line at the top shows the limit of satisfactory exhaust. It is seen that the most economical performance may be realised from about 1,300 r.p.m. to beyond 2,000 r.p.m., with a brake mean effective pressure of about 60 lb. per square inch. Further, allowing for a 10 per cent. margin within the curve of the limit of satisfactory exhaust, the maximum permissible brake mean effective pressure is 64·5 lb. per square inch, which is obtained over the range from 2,000 to 2,200 r.p.m.; this corresponds to a maximum torque of 72·6 lb.-ft., to an output of 27·5 to 30·5 brake horse-power, and to a specific fuel consumption of about 0·47 lb. per brake horse-power per hour. At the maximum speed, allowing the same margin, an output of 35 brake horse-power is developed. The results shown in this figure would be of considerable value to the designer of a vehicle in which this engine is to be the power unit. In particular, it may be observed that the overall consumption, expressed in miles per gallon, of the vehicle will be greatly influenced by the good or bad selection of the transmission ratios.

If the fuel consumption in lb. per hour, as given in Table I, page 387, *ante*, are plotted on a base of brake mean-effective pressure, some evidence may be obtained of the mechanical losses of the engine. Curves of this kind are given in Fig. 6, page 420, and, for the series A, D and E, the values at no-load have been added; these were obtained by measuring the fuel to drive the engine when running completely light. The points on such curves at the smaller loads fall on straight lines, and, if these are extrapolated to cut the base line, the intercepts give the mean-effective pressures corresponding to the total internal losses of the engine, expressed as frictional mean-effective pressure (F.M.E.P.). The values of the intercepts are: 22 lb. per square inch in series A, at 1,200 r.p.m.; 31 lb. per square inch in series D, at 2,400 r.p.m.; and 34 lb. per square inch in series E, at 2,800 r.p.m. The intercepts for series B and C are not taken, since the tests at light load were not made. The very small deviations of the test points from the curves deserve comment; they indicate the generally high accuracy with which the tests were carried out. The points for A, D, and E are plotted on the curve "F.M.E.P. Extrapolated" in Fig. 7, page 420.

In a second method, the electrical dynamometer was arranged to operate as a motor and provided a means of measuring the torque to drive the engine when "motored" with the fuel supply cut off. Precautions were taken to ensure that, as far as practicable, the temperatures of the engine were the same as those prevailing during normal operation. Two series were run, one with the blower in operation and one with the blower removed. The curves for these two series are plotted in Fig. 7. It will be observed that, as the speeds are raised, the curve "F.M.E.P. Motoring" rises increasingly above the curve "F.M.E.P. Extrapolated." A probable explanation for the lower values in the latter case is that, with fuel injection, the gases are helped to flow out of the cylinder by the pressures resulting from the combustion, leaving a lower pressure in the cylinder and thus necessitating less work to be done by the blower to scavenge and re-charge the cylinder.

In Table II, page 420, the values observed in each series of Table I for that test in which the B.M.E.P. falls nearest to 60 lb. per square inch are set out in the first three lines. The values of F.M.E.P. for each speed are then given, line M with the value "motoring" and line E with the value "extrapolated." These values, when added to those for B.M.E.P., give the corresponding values of indicated mean-effective pressure, I.M.E.P., in lb. per square inch. From these values, the values of the mechanical efficiency will seem low, but it must be remembered that the values of F.M.E.P. include the work done by the blower. Fig. 7 shows that this work, expressed as a percentage of the total mechanical losses measured by "motoring," increases from 20 at 1,000 r.p.m. to 47 at 2,800 r.p.m. The values of I.M.E.P. must be regarded as satisfactory, especially when it is remembered that they are based on the total stroke of the piston and not on the effective stroke, namely, that part of the stroke above the top edge of the exhaust ports. Some account should also

Fig. 4.

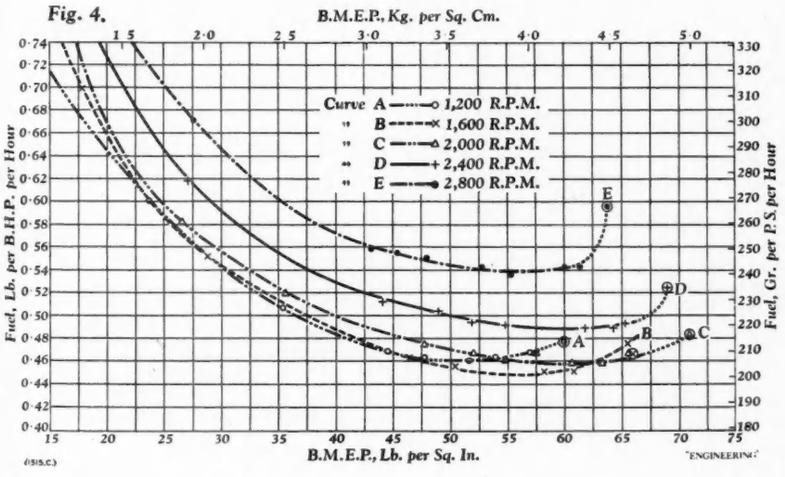

B.M.E.P, Kg. per Sq. Cm.
1·5 2·0 2·5 3·0 3·5 4·0 4·5 5·0
Curve A —○— 1,200 R.P.M.
" B - - -× 1,600 R.P.M.
" C —△— 2,000 R.P.M.
" D ——+ 2,400 R.P.M.
" E —●— 2,800 R.P.M.
Fuel, Lb. per B.H.P. per Hour
Fuel, Gr. per P.S. per Hour
B.M.E.P, Lb. per Sq. In.
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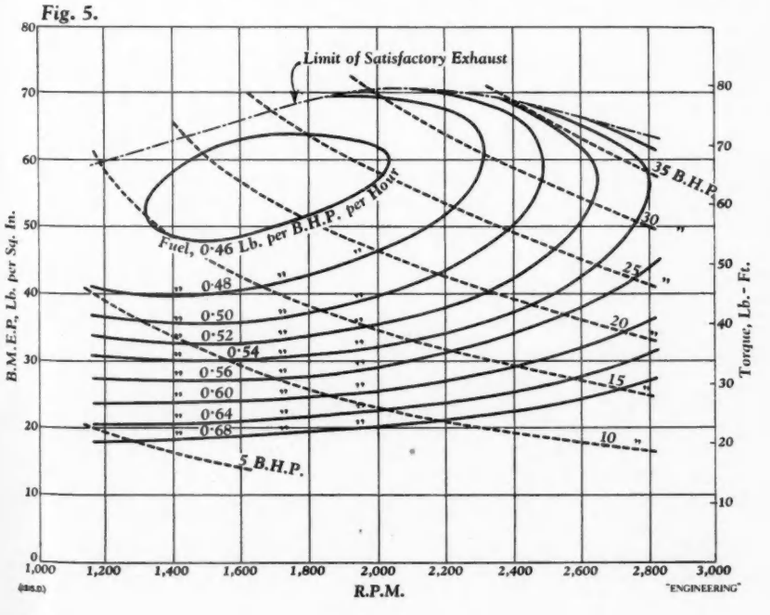
Fig. 5.



TWO-STROKE OIL ENGINE FOR AUTOMOBILES.

Fig. 6.

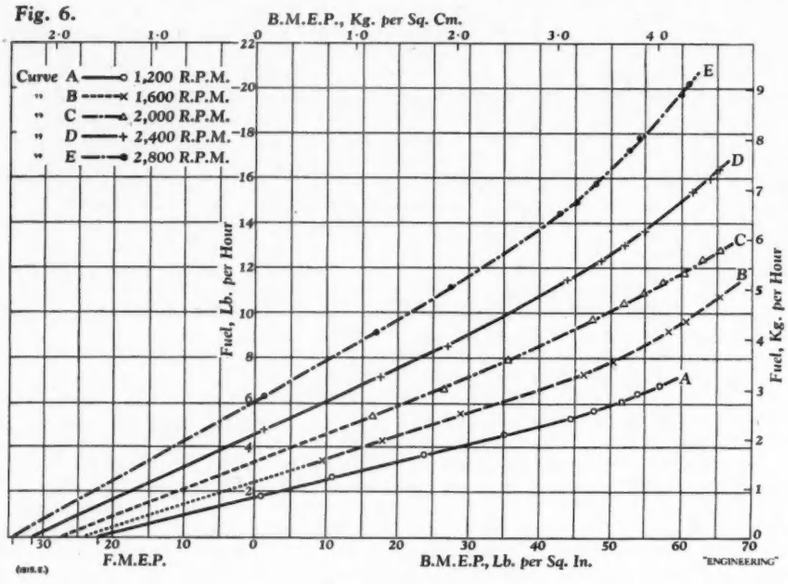
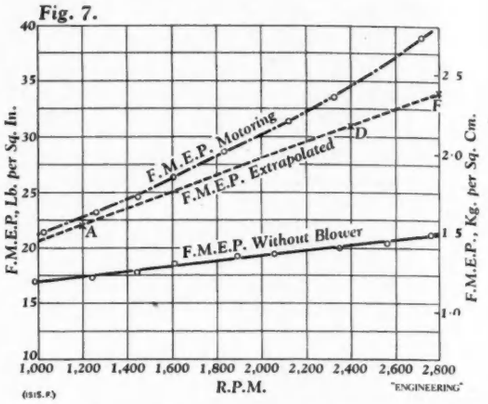


Fig. 7.



be taken of the low barometric pressure, 0·97 of standard. The values of indicated thermal efficiency are high for such small cylinders, particularly when consideration is given to the fact that the volume to surface relationship, as cylinder sizes are reduced, decreases in proportion to the linear dimension, so that the heat losses may be expected to lead to progressively greater lowering of the thermal efficiency. Each value is, of course, the integration of all the factors of combustion; these factors comprise the correlation of the injection characteristics with the combustion chamber form, and also the efficacy with which the scavenging of the exhaust gases and the re-charging of the cylinder with pure air are carried out. Evidence that these processes are satisfactory is given by the high values found over the wide range of speed from 1,200 r.p.m. to 2,800 r.p.m.

While carrying out the five series, A to E, observations were taken during roughly alternate tests of the air taken by the engine. This air was measured by passing it through a rotating-piston gas meter, made by the Julius Pintsch Company, of Berlin. The necessary readings of pressure and temperature were taken and the volumes measured were converted to those corresponding to the prevailing atmospheric conditions. The values obtained were then divided by the corresponding values of the total swept volumes of the pistons and the quotients were expressed as the gross volumetric efficiencies of the engine, λ_0. The values of λ_0 so obtained are given as the points on the curves in Fig. 8, plotted on a base of B.M.E.P. The mean value over the complete range of speed and load is seen to be 1·4. All five curves have a slight downward general slope with increase of B.M.E.P., but the extreme values for each series are within a range of 0·04, and the extremes for all the series fall within $\pm$ 0·04 relatively to the mean value 1·4. A consistency of delivery of this order is, of course, to be expected from an accurately made Root's blower; but, for a blower applied to an engine, this consistency will only be given if the air supply is properly correlated with the scavenging and charging conditions of the engine.

A separate investigation of the characteristics of the blower was undertaken in the absence of the author, by the engineers of the List organisation. The author, however, had previously made measurements using the test equipment and accepts their results as accurate. The results of this investigation are given in Fig. 9. The base of this figure gives volumes of air under atmospheric conditions; the ordinates give the ratio of the pressures, p_2, after the blower to the pressures, p_1, before the blower. The three sets of curves given in the figure are, respectively, for constant speed of the blower, for constant adiabatic efficiency, and for constant brake horse-power. In the tests, the blower was driven by a motor arranged on a stand to measure the torque reactions to drive it, from which, with observation of the speeds of revolution, the horse-power was calculated. The adiabatic efficiencies were calculated by dividing the powers assuming adiabatic conditions by the horse-powers from the torque-reaction values. For a Root's blower of the size in question, for which the delivery volume per revolution is 0·0547 cub. ft. (0·001551 cub. m.), the values of the adiabatic efficiency are high. It will be recalled that the blower is driven by V-belts. With the normal rate of air supply the blower runs at 1·87 times the engine speed, so that the range 2,000 to 2,800 r.p.m. corresponds to a range of blower speed from 3,740 to 5,240 r.p.m. The highest values of the adiabatic efficiency are thus only reached near the top of the speed range with this rate of air delivery.

Changes in the rate of air delivery from the blower can be made by changing the ratios of the diameters of the pulleys of the drive to the blower. Changes in this rate may be expected to bring about changes in the combustion and other conditions in the cylinder, and so to affect the values of the I.M.E.P. obtained; on the other hand, such changes of rate will involve corresponding changes in the energy expended in driving the blower, and these will affect the values of F.M.E.P. From the practical point of view, the principal matters are the resulting values of B.M.E.P. and brake specific consumption. An investigation of the effects of changes in the rates of air delivery is thus of considerable interest and was carried out for a range of values of λ_0 from 1·15 to 1·6.

Fig. 10 shows the results of "motoring" tests carried out over the engine speed range from 1,000 to 2,800 r.p.m. with five rates of air delivery; the results are plotted as F.M.E.P. on a base of engine r.p.m. The additional curve F is taken from Fig. 7 and gives the values of F.M.E.P. without the blower. The intercepts between any one of the curves A to E and the curve F show, for the particular speeds taken, the equivalent parts of the value of F.M.E.P. necessary to drive the blower. Curve C for $\lambda_0 = 1·4$ corresponds to the conditions under which the main series were run, and is seen to lie below curves A and B and above curves D and E.

The next observations made were those of the "limits of satisfactory exhaust" with the different rates of air delivery. The results are shown in Fig. 11, plotted as B.M.E.P. on a base of engine r.p.m. Allowing a suitable margin, such curves give, of course, the effective outputs of the engine over the range of speed. It is seen that curve C, with the engine as normally arranged, gives the best results. Curve B is only slightly inferior at the low-speed end, but the best practicable values are obviously desirable here. The other curves are markedly inferior.

The next most vital factor is the brake specific consumption at normal load, and a series of tests was made with brake loads corresponding to a B.M.E.P. of about 57 lb. per square inch (4 kg. per square centimetre), over the speed range from 1,200 to 2,800 r.p.m., with the same five rates of air supply. The results are shown in Fig. 12, plotted as brake

Table II.

Test No.	A 10.	B 7.	C 8.	D 8.	E 9.
R.P.M.	1,190	1,630	1,955	2,365	2,790
B.M.E.P., lb. per sq. in.	60·0	60·9	60·6	61·9	60·0
Brake specific consumption, lb. per hour	0·478	0·453	0·460	0·490	0·544
F.M.E.P., lb. per sq. in.	M 22·5 E 21·9	26·5 25·5	29·6 27·7	34 30·8	40·0 33·7
I.M.E.P., lb. per sq. in.	M 82·5 E 81·9	87·7 86·4	90·2 88·3	95·9 92·7	100·0 93·7
Mechanical efficiency, per cent.	M 72·7 E 73·3	69·4 70·5	67·2 68·8	64·5 66·7	60·0 64·0
Indicated specific consumption, lb. per hour	M 0·348 E 0·350	0·314 0·320	0·309 0·316	0·316 0·327	0·326 0·348
Indicated thermal efficiency, per cent.	M 37·5 E 37·2	41·5 40·7	42·2 41·3	41·3 39·9	40·0 37·5

TWO-STROKE OIL ENGINE FOR AUTOMOBILES.

Fig. 8.

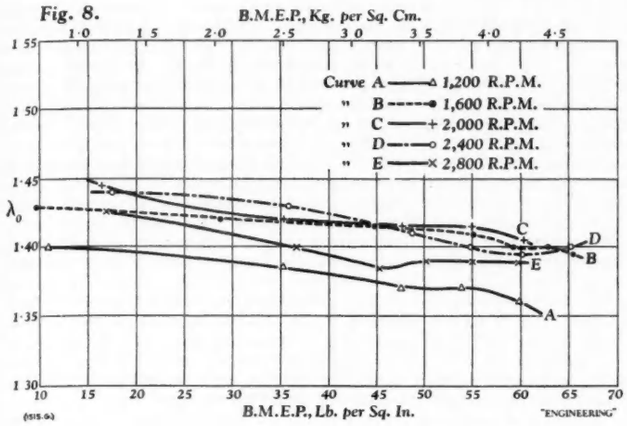


Fig. 9.

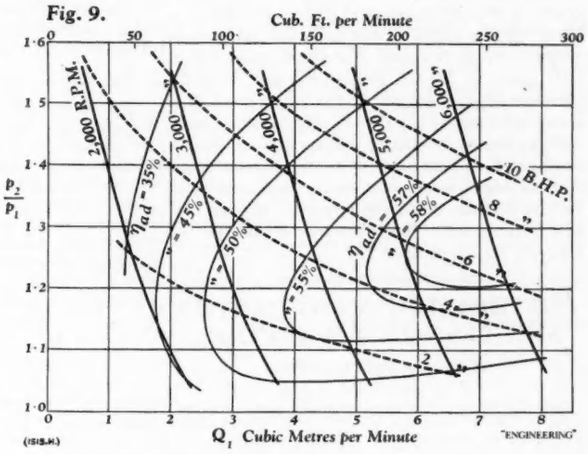


Fig. 10.

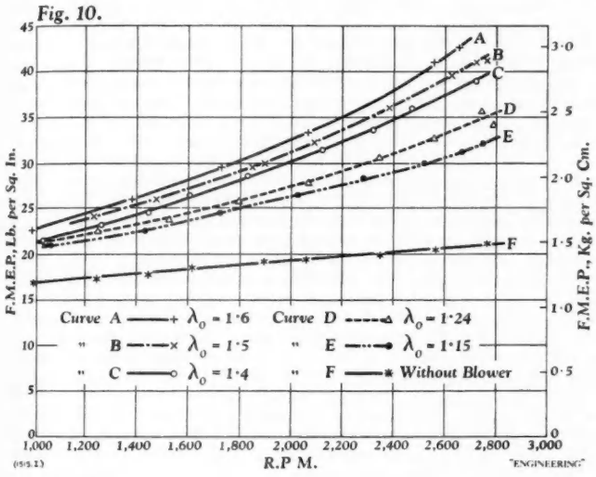


Fig. 11. LIMIT OF SATISFACTORY EXHAUST.

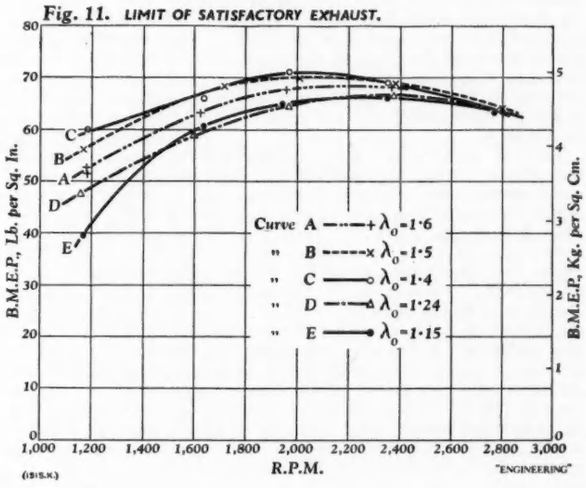


Fig. 12.

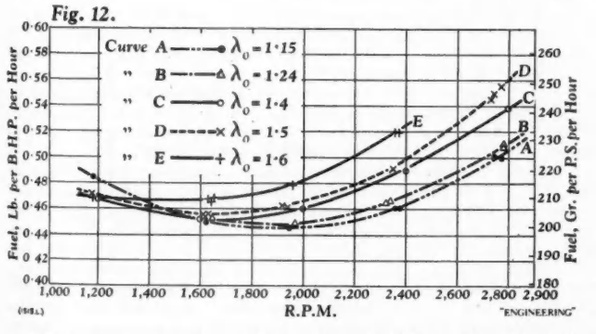
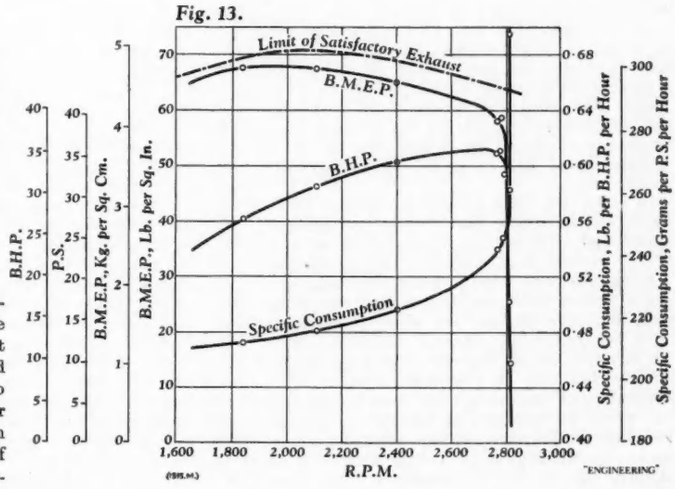


Fig. 13.



specific consumption on a base of r.p.m. Here it will be seen that curve B is better than curve C for the normal conditions, especially for the upper part of the speed range. Curve A is also good at the higher speeds but falls off at the lower speeds. Clearly the designer is faced with the need to choose between the two desiderata: the best torque characteristic or the best economy characteristic. The answer should be in accordance with the conditions of application of the engine. In the present case, as the results show, the decision has been to accept the somewhat less favourable fuel economy as the price to pay for a superior torque characteristic.

In the practical application it is desirable to restrict the fuel supply, on the one hand, so that the combustion is not pressed too far towards an unsatisfactory exhaust and, on the other, so that the engine cannot exceed its desirable maximum speed of revolution. Fig. 13 shows the results of tests, carried out after the author's departure by the engineers of the List organisation, in which the pump lever (or accelerator pedal) is in the maximum output position over the speed range from 1,800 to 2,800 r.p.m., the latter being the maximum desirable speed of running, as determined by the governor and pump settings. The curve obtained for the "limit of satisfactory exhaust," and given in Fig. 5 and 11, has been added. The values of the B.M.E.P. are seen to allow for a reasonable margin in relation to the "limit of satisfactory exhaust." The curve of B.H.P. comes to a maximum value of 35 h.p. at 2,700 r.p.m., and then falls off rapidly as the maximum speed is approached as a result of the governor coming into action.

The petrol engine for automobiles has been brought to a very high level of flexibility, smoothness of running, and absence of noise. Its drawbacks are its relatively high fuel consumption, especially under traffic conditions, and the difficulty of starting in very cold weather. An oil engine of the kind under test gives a more certain start at low atmospheric temperatures but its main advantage lies in its greatly superior fuel consumption, as measured in transport service in miles per gallon. The designers of the engine under investigation have successfully developed an engine in which ease and cheapness of manufacture have been taken into

account but, as the test results show, not at the expense of satisfactory performance. Consideration of Figs. 1, 2 and 3, indicates that the power could be readily increased by 50 per cent. in a three-cylinder engine of the same unit dimensions with an increase in overall length from about 23½ in. (595 mm.) to 29¼ in. (745 mm.), and with the corresponding uniformity of turning moment of a six-cylinder four-stroke engine. By building a four-cylinder engine in V-form, the power could readily be doubled with no increase in overall length, and such an engine would have the same uniformity of turning moment as an eight-cylinder engine; for this arrangement, the auxiliaries would be re-arranged for compactness.

THE BRITISH ASSOCIATION MEETING IN LIVERPOOL.

(*Continued from page* 391.)

District Heating.

The President, Lord Dudley Gordon, occupied the chair in Session B on Monday morning, September 7, and invited Mr. A. E. Margolis to deliver his paper on "District Heating," which will be reprinted in an early issue of Engineering. The author presented the paper in somewhat abridged form, but at its conclusion the chairman pointed out that the time remaining was only sufficient for a few questions, which the author would answer individually.

The first speaker, Miss. M. V. Griffith, said she must dispute the author's statement that electricity could not be stored. Off-peak electricity could be stored very usefully as heat in concrete domestic space heaters and in concrete floors and foundations; also in hot-water storage tanks, as the author had himself acknowledged in the later part of his paper. Commenting on the reference by Mr. Margolis to the paper by Dr. D. H. Parry on the logical approach to electrical space heating, Miss Griffith said it was being implemented by the Utilisation Committee of the British Electricity Authority who were shortly putting into practice the principles of a very high degree of heat insulation in a new housing estate, and she assured the meeting that the rate of ventilation would be quite adequate for health purposes. The loading, which was stated to be not sufficient for continuous heating or heat storage, had been proved by tests to be adequate. Mr. Margolis's paper dealt with additions to power-station capacities, but the speaker pointed out that heat would still be lost in cooling water, even if back-pressure sets were added. She asked why the use of the heat pump had been rejected so firmly for the Pimlico housing estate and concluded by stating that the whole problem would not be solved by adding back-pressure sets.

In reply, Mr. Margolis said the storage of hot water was so simple that it was not generally appreciated; the storage of small quantities, he added, was rather expensive, but storage in large volumes was very cheap. They were aiming at power station efficiencies higher than the 22 per cent. known in the past and expected efficiencies of 26 per cent. to be obtained generally by 1960. An efficiency of 30 per cent. had been reached already, but only in exceptional stations. The application of heat pumps had been investigated, but would be expensive as heat pumps required too much maintenance. If they could also be used for air conditioning one room they would be satisfactory, but for air conditioning a whole house they were too expensive. Electricity was such a convenient commodity that it should not be wasted for space heating; it was too costly for that application.

The only other speaker, Dr. Kenneth Hutton, said he was a resident in a new town and he would like to know at what distance from a power station it was economical to use district heating. To this question, Mr. Margolis replied that the answer depended upon the magnitude of the installation. In a system of sufficient size, he thought hot water could be supplied economically at distances of six miles, or perhaps even 10 miles. It was a question of the integration of district heating with electricity generation.

At this point the Chairman said it was necessary to adjourn the meeting for a short interval before taking the next paper, and he expressed the thanks of the members to Mr. Margolis for his paper.

The Efficiency of Heating in Buildings.

The second paper taken in Session B was by Mr. A. T. Pickles, O.B.E., who was briefly introduced by the chairman, Lord Dudley Gordon. The paper, which was entitled "The Measurement of the Efficiency of Heating in Buildings," was essentially a recapitulation of the detailed researches on the heating of buildings carried out by the Building Research Station, Garston, Watford. As these researches have been extensively published, it is thought that the following summary, together with the appended list of references,* will suffice to give an indication of the nature of its contents.

Most of the known facts, as well as most of the possible opinions, concerning the efficient use of fuel in this country are given in the report of the Committee on National Fuel Policy (the Ridley Committee) which was published at the end of last year. The subject is now so thorny and complex that no account of the general problem of fuel economy can usefully be given on a smaller scale than that of this report and its attached appendices. One important interest of the engineer and scientist lies in the reduction of the area of opinion and the increase in factual knowledge; this has been attempted in a series of detailed experimental researches on the heating of buildings carried out at the Building Research Station since 1946. The work on small houses was carried out in 44 houses built on the Station's experimental site at Abbots Langley, in Hertfordshire, and has subsequently been generalised by work in collaboration with local authorities, and by survey techniques. Subsequent work has been concerned with the heating of schools and factories, and an experimental assessment of the efficiency of a small district-heating plant for houses was carried out. In all this work the essential condition has been that the buildings should be normally occupied. The results obtained relate to the way in which ordinary families live in the typical small local-authority houses built since the war, and similar results for normal use have been obtained in schools and factories. This has been effected by the extensive use of recording instruments; in the experimental houses the temperature in each room was continuously recorded by day and night for over four years, in some instances, using a system of multicore cables connecting the thermometers in the houses to central recording stations. The ventilation rate was measured from outside the houses by the use of helium as a tracer gas, detection being carried out by thermal-conductivity bridges. The heat intake was calculated in terms of the solid fuel delivered, and the electricity or gas was metered. This work has led to the rehabilitation of the open fire, in an improved version and fitted with a back boiler, as the recommended heating system for small houses.

Similar measuring techniques were used in factories and also in schools. By arrangement with the Hertfordshire County Council a new primary school near the Station was designed to have two classrooms heated by forced warm air, two by floor heating and two by conventional radiators, and the amount of heat used by these three different types of heating equipment was measured in relation to the temperatures, temperature gradients, ventilation rates and air currents in the classrooms. The results showed a substantial fuel economy with the warm-air method of heating in schools with conventional operation of the systems. They served, however, to emphasise the essential feature of fuel economy, namely that the heat service must be related to the needs of the occupants. Schools are only occupied for about 20 per cent. of the time, so the economy with a very flexible system like warm-air heating is readily understandable, and research is now proceeding on the control systems for radiator and floor heating in order to increase their flexibility.

The results of the large programme of detailed experimental work have all been published in the technical Press, so that they have been available to the designers. Similar work is now being undertaken by other authorities, and at the same time a great deal of practical experience has been accumulated during the post-war years. The possibilities of fuel saving in buildings are seen to be related to the needs and habits of the occupants and the use of the building; and the various types of buildings, such as low-density housing, flats, offices, factories, schools and hospitals, are found each to have special features which are almost, if not equally, as important as the primary requirements of efficient combustion and good thermal insulation.

The first speaker in the discussion on the paper was Wing-Comdr. T. R. Cave-Browne-Cave, C.B.E., who said he gathered from Mr. Pickles that air temperature was taken as the criterion of effective domestic heating, but he wondered if that were correct, because it seemed to him that what really mattered was the effective comfort of the occupants. He had in mind the University library at Southampton, which was equipped with floor heating. The floor temperature was about 70 deg. F., but the air temperature was considerably lower. With their feet on the slightly warmed floor, the students were very comfortable, air being admitted only under control, but with ceiling heating their feet would not be warm and they would be uncomfortable. Recalling some observations on the heating of passenger service vehicles, he said it had been found that a temperature difference of 15 deg. F. between the inside and outside air was quite sufficient, but for classrooms and living-rooms the assessment of comfort was much more difficult.

In reply, Mr. Pickles said the question of the adequacy of a given type of heating was probably a second-order effect. It was a matter of common observation; it was very difficult, on a mass scale, to find a performance factor, or to conceive of a large-scale experiment which would show that any substantial saving of fuel could be effected. The requirement was to find an experiment which would translate what was a matter of observation into a plain measurement of fuel saving. In connection with the heating of schools, for instance, the number of children attending and the frequency of occupancy were definite design factors.

Professor W. Fisher Cassie asked what Mr. Pickles considered to be the effect of the insulation used in a small house. He had been surprised, even shocked, to hear the recommendation for the use of open coal fires, even if they were of the improved type with a thermal efficiency of 45 per cent., when equipment of higher efficiency was available. His surprise arose chiefly from the serious problem of atmospheric pollution and he inquired whether Mr. Pickles had considered that aspect or whether his recommendation had been based only on fuel cost.

To the first part of Professor Cassie's question Mr. Pickles replied that the heat loss through a ceiling into a roof space was of the order of 0·4 B.Th.U. per deg. F. per square foot per hour, but if glass wool, or practically any heat insulation of that kind, were used above a ceiling the corresponding loss was about 0·08 unit, so that a really substantial increase of thermal resistance in the ratio of 5 : 1 was obtained. Most people who had employed insulation in this way, he believed, were very satisfied. Regarding atmospheric pollution, he said it was probably true that the whole 180 to 200 million tons of coal used in this country was causing some pollution. As about 14 million tons were used by the railways and more than 100 million tons were used in industry, it was possible that the ordinary domestic consumer was getting rather too much of the blame. There was no doubt that a great deal of improvement must come from industry or even from electricity generation. The reason for making the recommendation referred to was that

* Report of the Committee on National Fuel Policy and the use of Fuel and Power Resources. (The Ridley Report.) Cmd. 8647. September, 1952; Western, J. C., Heating Research in Houses. *Jl. Inst. Heat. Vent. Engrs.*, vol. 22, pages 590 and 593 (1949); Weston, J. C., Heating Research in Occupied Houses. *Jl. Inst. Heat. Vent. Engrs.*, vol. 19, pages 47 to 108, 1951; Dick, J. B., and Thomas, D. A., Ventilation Research in Occupied Houses. *Jl. Inst. Heat. Vent. Engrs.*, vol. 19, pages 306-326, 1951; Weston, J. C., School Heating Research. *Jl. Inst. Heat. Vent. Engrs.*, vol. 20, pages 459-494, 1953.

people had to live in the houses that were built, and it was felt that it might be advantageous to advance even half in step in efficiency rather than to wait for a complete answer.

The discussion was continued by Miss M. V. Griffith, who said that it was important, when making a study of any particular method of heating, that it should be operating under favourable conditions. Floor heating, for instance, was nearly always installed without insulation beneath and around the floor slabs. The heated floor slab might form part of a much larger unheated slab to which heat would escape, thus rendering the system inefficient. If two systems were being compared in two adjoining rooms, one heated by conventional methods and one by a floor slab, heat might flow into the conventionally-heated room because the floor was usually the coldest part of such a room. Miss Griffith thought it was a little unfair to relate the arguments put forward in the paper to larger buildings. If sufficient publicity were given to important work, such as that described in the paper, in connection with, say, domestic heating and a method was thereby condemned, it was not always considered on its merits for application to a larger building for which it might be more suitable. Considerable satisfaction had been expressed on all counts by the users of large floor-heating installations in Scotland, for instance, which were mainly operated off-peak under thermostatic control. Commenting on curves shown by the author to illustrate how living-room temperatures fell with the outside temperature, Miss Griffith suggested that this might be due in some cases to inadequacy of the heating appliances used. Mr. Pickles, referring only to the last point, said this was almost certainly true in the case of some appliances, but not in others.

Dr. Kenneth Hutton asked for information on the relative costs of different forms of heat insulation which he said ranged from 9*s.* 6*d.* to 2*s.* per square yard. He had been informed that each was composed of about 1 in. thickness of bitumen-bonded fibre glass. Mr. Pickles replied that people at the Building Research Station were great believers in insulation and did what they advised others to do; they would use any insulating material provided it was cheap. He had insulated his own house with glass wool costing about 2*s.* 6*d.* per square yard and had felt much more comfortable in consequence.

The last speaker, Mr. W. L. Howe, referring to schools, said all heating systems were open to competitive tender and were usually designed on a fairly arbitrary temperature basis, such as 30 deg. F. outside and 60 deg. F. inside. If the external temperature fell below 30 deg. F., the occupants of the building would take steps to maintain the internal temperature; obviously they would close the windows. Mr. Howe inquired whether, if there were insulation, it would maintain the internal conditions with an air change at the rate of 2½, or even 3, per hour. Referring to the fact that at the present time many of the schools were single-storey buildings with large areas of glass, he asked whether, irrespective of the fuel used for heating, the nation could afford such luxuries. In other words, what was the fuel equivalent of a modern school compared with that of a pre-war multi-storey school with the same accommodation?

In a brief reply, Mr. Pickles said that one of the reasons for lining with glass wool in a school was that it was cheap, and it was a question of striking a balance. Regarding the buildings themselves, most of the single-storey schools were primary schools, but the secondary schools built during the next three or four years would be multi-storey buildings. He did not think the difference between pre-war and post-war practice was as great as Mr. Howe had implied.

After a vote of thanks to the author had been proposed by the chairman and carried by acclamation, the session was adjourned.

(*To be continued.*)

EXTENSION OF DUNFERMLINE POWER STATION.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the extension of the Dunfermline power station by one 12·5-MW turbo-alternator and two boilers, each with an evaporative capacity of 80,000 lb. of steam per hour. The present installed capacity of the station is 13 MW.

ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

THE fourth joint conference of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences (of the United States) was concluded in London on Thursday, September 17. As noted on page 371, *ante*, the opening of the conference on Tuesday, September 15, was preceded by a reception at the Royal Aeronautical Society following the Wilbur Wright Memorial Lecture presented the previous evening. At the conclusion of the conference a dinner and dance were held at the Dorchester Hotel, at which the President of the Royal Aeronautical Society, Sir William Farren, announced that H.R.H. the Duke of Edinburgh had become an Honorary Fellow of the Society.

During the three working days of the conference, twelve papers were presented and discussed, covering various aspects of aircraft structures, power-plant installations, aerodynamics, helicopter design, instruments, de-icing, production and commercial jet operation. Certain of these papers were of a specialised nature, while others were surveys of broader character; we propose here to summarise only those of the latter group.

STRUCTURES FOR HIGH-SPEED AIRCRAFT.

The problems of the structural designer, and methods and materials for their solution, were discussed in a paper by Mr. H. L. Hibbard and Mr. J. F. McBrearty, entitled "Structures for High Speed Aircraft." The high-speed military aircraft, they said, might have to withstand considerable thermal radiation from atomic bomb explosions, etc., as well as the boundary-layer temperature rise which amounted, in deg. F., to 75 times the square of the Mach number. There were available materials with a comparatively high strength-to-weight ratio at elevated temperatures, but nevertheless the resulting structures would have to be heavier than those adequate for a normal temperature environment. The distorting effects of non-uniform temperature on the aerodynamic contour could be reduced by the use of thick load-carrying skins and closely-spaced ribs or webs.

With the advent of nuclear power plants, materials were required which were not damaged by radiation and which did not themselves become radioactive. The design of the airframe might have to cater for remotely-controlled servicing and maintenance procedures; large fuel loads would no longer provide bending relief for the wing structure, but the latter could be simpler in the absence of fuel tanks. If the crew quarters required heavy shielding, the dynamic vertical bending of the fuselage under gusts might impose more severe requirements than hitherto. The landing gear and associated structure would have to be stronger since the difference between take-off and landing weights would be negligible.

Structural fatigue had become increasingly important as a result of the steady reduction of design load factors, increased utilisation, and the use of new materials with higher static strength properties, but with fatigue properties which had not kept pace with the static strength. To avoid fatigue troubles, the introduction of residual tensile stresses was avoided by hot-forming and other methods, stress-concentrations were analysed, and fatigue-testing of complete structures was becoming general practice. For the detection of fatigue, a warning device, consisting in principle of a pack of test specimens with graded stress concentrations, bolted to a structural member, might help in forecasting trouble in an individual aircraft.

In large flexible aircraft with thin wings, transient loading phenomena, in which the rate of deformation with time was significant, were becoming increasingly important. Discussing structural design methods, the lecturers described a flight testing technique developed by the Lockheed Aircraft Corporation, California, in which small-scale structures were mounted on the motor section of a high-velocity aircraft rocket, and their behaviour was photographed and observed from the camera film recovered. Recently, telemetered flight had begun to furnish quantitative data. Problems of analysis still to be solved included a practical method of simulating temperature effects in large structural tests, and a direct means for separating thermal strains from air-load strains in diving flights.

Among the structural materials discussed, the lecturers cited a new aluminium alloy, 78ST, with tensile and compressive yield stresses of 67,000 lb. and 66,000 lb. per square inch, i.e., 6 to 10 per cent. higher than those of 75ST. The lecturers considered that, although the tensile strength could rarely be exploited, the high compressive strength could give useful gains except in very thin, high aspect-ratio wings, where titanium and steel began to be competitive. They mentioned an interesting example of an integrally-stiffened aluminium-alloy structure, the inner-wing box-beam lower surface on the Super Constellation, which, in comparison with the conventional riveted structure it replaced, saved 17 per cent. in weight, and required only 19 per cent. of the parts and less than 18 per cent. of the rivets, bolts, etc.

Another material cited was SAE 4340 steel, heat-treated to the highest level at which it could be consistently tempered (260,000 lb. to 280,000 lb. per square inch). This material gave a larger spread between yield and ultimate tensile strengths than the previously-used temper (about 180,000 lb. per square inch), and also showed a higher notched endurance ratio. Machining was more difficult, but still practical, with the same feeds and speeds. For higher temperatures, titanium alloy was the most efficient material, with a strength-to-weight ratio at moderately high temperatures comparing favourably with that of the more common materials at room temperatures.

FATIGUE OF AEROPLANE STRUCTURES.

The effects of design trends on aircraft structural fatigue, and means for avoiding catastrophic crack spread, were discussed in a paper entitled "Some Observations on the Fatigue of Aeroplane Structures," by Mr. Richard V. Rhodie. Aircraft primary structures, Mr. Rhodie said, were designed principally on the basis of static strength requirements under gust loads. From a consideration of the affects of the design load factor, the design speed, wing loading, and static structural efficiency, the lecturer concluded that the only significant factor affecting the fatigue life was the static structural efficiency. Continuous improvements in the strength-to-weight ratios of materials had resulted in higher design stresses, which increased both the mean stress and the fluctuating stress amplitudes that the aircraft structure had to withstand. Thus the primary tension material of wings showed a pronounced tendency to a shorter fatigue life as the structural efficiency increased, and a corresponding tendency towards catastrophic fatigue failure. Little relief of the gust problem could be expected for high-altitude jet aircraft, since they had to climb and descend through the more turbulent air levels at high indicated air speeds.

Turning to methods of attacking the fatigue problem, Mr. Rhodie said that the analytical prediction of fatigue life was not, and probably never would be, possible. The practical testing of complete structures under a given spectrum of repeated loads was expensive and time-consuming. Fatigue-warning devices included counting accelerometers and strain gauges, crack-detection wires and fatigue-damage monitors; the indications were of little value unless correlated with full-scale results. The use of cargo aeroplanes, suitably instrumented, to act as fatigue monitors for identical passenger aeroplanes, had also been suggested.

Although attention to detail design could improve fatigue life, it gave no guarantee that fatigue cracks would not occur nor that they could be detected before propagation. Gust-alleviating devices, the lecturer said, had sometimes been advocated for reducing design loads and structural weight; this practice might introduce greater numbers of small loads with adverse effects on fatigue life and on the loads on the tailplane.

The degree of redundancy of a structure was of great importance in avoiding catastrophic failure. Large reductions in strength could be caused by small fatigue cracks, not readily detected, in relatively heavy members such as spar flanges.

On the other hand, in structures in which the skin and stiffeners comprised the main tension material, cracks could easily be detected before large losses of strength occurred. The type of static failure resulting from a fatigue crack was more important than the fatigue life, because the type of failure was related to the rate of loss of static strength and to crack detectability. It should be possible in the laboratory to determine the factors governing the type of failure.

Metal-to-Metal Bonding.

The paper on "Structural Adhesives for Metal Aircraft" presented by Dr. N. A. de Bruyne formed a comprehensive reference work on the applications, joint strengths, production techniques and inspection procedures for metal-to-metal bonded structures. The application of metal adhesives to aircraft structures, Dr. de Bruyne said, could result in lighter structures with stronger joints and a longer fatigue life. They had a smooth external finish, generally simplified design and maintenance, facilitated the pressure-sealing of cabins and fuel tanks, and reduced production costs and times. The principal disadvantage of structural adhesives was their unsuitability for high-temperature operation.

For providing stability under compressive loads, sandwich construction offered great advantages. In this, the aircraft shell was constructed as an "I-beam" with the web, not necessarily of the same material as the flanges, expanded by reticulation to the same width as the flanges. Synthetically-expanded cores could be solid foams or mechanically reticulated materials such as "honeycombs," which had better mechanical properties. Bonded metal honeycomb structures had a high structural efficiency and could result in great weight saving compared with stringer-stiffened structures; they had a smooth rigid outer surface, required no ribs, and were easily constructed by bonding under a rubber blanket or bag with a vacuum of about 12 lb. per square inch. With Redux adhesive, the curing temperature need not exceed 145 deg. C. It was possible to bond flat honeycomb to a curved skin, and it could be cut to aerofoil section by a high-speed horizontal band saw suitably guided.

Speaking of the bonding process, Dr. de Bruyne said that the preparation of the surface was of primary importance for obtaining consistent high-strength joints. The joint could be formed under pressure by vacuum blanket, internal-pressure bag, mechanical spring-loaded clamps, in an autoclave, or in a hydraulic press. The latter method, using steam-heated platens, was most widely adopted in Europe. In the Redux process, the metal surface was degreased, then pickled or etched and washed; Redux liquid (phenol formaldehyde) was applied to the clean surface, which was then dipped in Redux powder (polyvinyl acetal). The surfaces were then heated to about 140 deg. C. under moderate pressure for about 20 minutes. The lecturer emphasised that carefully controlled inspection was essential to successful bonding. Redux-bonded simple aluminium-alloy lap joints of 100 per cent. efficiency could be made if the sheet thickness did not exceed about 26 s.w.g., whereas it was difficult to exceed more then 60 per cent. with a similar riveted or spot-welded joint. For thicker sheets double lap joints or scarfed joints gave more efficient results. At 100 deg. C., a lap joint cured at 165 deg. C. for 20 minutes showed a strength of about one-quarter of that at room temperature; the high-temperature strength could, however, be raised considerably by longer curing or subsequent heating, and for civil aircraft, present adhesives would be useful for some time to come. In comparative strength tests at the Nationeal Luchtvaartlaboratorium on riveted and Redux-bonded stringer-skin panels, the latter had a 20-per cent. higher static failing load, and under push-pull loads of amplitude 45 per cent. that of the static failing load, the bonded panel had a life 15 times longer than that of the riveted panel.

Electro-Thermal De-Icing.

Methods of airframe and propeller de-icing developed at the National Aeronautical Establishment (N.A.E.) of Canada were described in a paper entitled "Aircraft De-Icing by Thermal Methods," by Mr. J. L. Orr, Mr. D. Fraser and Mr. J. H. Milsum. The system adopted allowed ice to build up, but shed it at intervals before it could have serious effects. In comparison with anti-icing systems, in which ice was prevented from forming at all, this resulted in an intermittent drag increase as the ice built up, but it required only comparatively small amounts of energy to break the bond between the ice and the aircraft surface. In the thermal system, the protected area was divided into several segments, isolated from each other, to which heat was applied in turn, so that the continuous heating load could be kept low. Since the ice was removed by aerodynamic or centrifugal forces, it was desirable to build up the ice between sheddings to ensure that these forces were adequate; surface heat was then applied for a short time to produce a film of water reducing the adhesion of the ice. A high specific heat input over a short period generally required less total energy than a low input over a longer period. After shedding, rapid surface cooling was required to avoid water running back and freezing on an unheated part of the surface.

In its application to propellers, power was usually supplied from the aircraft electrical system through slip-rings to conducting-rubber heating elements cemented to the leading edge of the blade, and extending from about 50 per cent. to 75 per cent. of the blade radius; it was not continued to the tip on account of stone abrasion and raindrop erosion effects. Chordwise, the element extended to about 15 per cent. on the camber face and 30 per cent. on the thrust face. The shedding cycle was composed of two completely independent factors, the icing period and the heating time. Ice was usually shed from all the blades simultaneously when it had built up to a thickness of $\frac{1}{16}$ in. to $\frac{1}{4}$ in.; the heating time required was primarily a function of the ambient temperature. Tests had indicated an optimum energy consumption of about 15 watts per square inch of surface at — 10 deg. C., and a typical instantaneous power input was of the order of 800 watts per foot of protected blade length.

The wing de-icing system comprised (i) a continuously heated parting strip along the stagnation line, which parted the ice-cap formed on the leading edge into two aerodynamically unstable halves; (ii) cyclically-heated shedding zones extending to about 5 per cent. chord on both surfaces immediately behind the parting strip; and (iii) continuously heated dividing strips, 1 in. to 2 in. wide, to prevent "bridging" the ice to adjoining cold sections. For the parting strip, a typical specific heat input was 20 watts per square inch. The temperatures of the parting and dividing strips were controlled to avoid overheating, which was not only uneconomical but also detracted from the shedding performance. It had been found that shedding time decreased progressively up to an ice thickness of $\frac{1}{4}$ in. The optimum specific powers in the shedding zone ranged from about 10 watts per square inch at — 10 deg. C. to 15 watts per square inch at — 20 deg. C. As an alternative to electrical heating, hot-gas de-icing could in some cases result in a lighter installation, but required a more complicated leading-edge structure and distribution valves. It also introduced thermal stresses into the basic wing structure, and suffered from thermal lag effects.

Protecting helicopter blades from icing was basically similar to protecting propeller blades, but the centrifugal forces available for ice removal were lower; and the extent of ice formation on the thrust face would be farther aft and, owing to reverse flow over part of the retreating blade in forward flight, there would be some minor ice accretion on the trailing edge. It was necessary to protect the blade tips.

The fully automatic control system comprised an anti-icing control, turned on by a signal from an orifice-type ice detector, which maintained heat in the parting-strip areas so long as ice was present. A high heat concentration was used initially after the first icing signal, but was reduced to the continuous level by the first shedding. A temperature-sensing element near the surface controlled the continuous heat input to the parting strips; alternatively, it might be possible to control the supply voltage to the strips by using one generator with a temperature-regulated field. The de-icing cycle was initiated by counting the number of signals from an orifice-type detector; heat was then applied in turn to the shedding zones by sequence switching, the length of heating time being controlled by the ambient temperature.

In conclusion, the authors gave an example of an installation for a propeller-turbine transport aircraft with an all-up weight of 60,000 lb., a span of 100 ft., and a cruising speed of 350 m.p.h. at 20,000 ft., fitted with four three-blade 14-ft. diameter propellers. Two 45-kVA 400-cycle 208/120-volt alternators, operating close to their rated output at all times, were proposed; the cyclic load comprised 40 to 50 per cent. of the total load. Should one alternator fail, the propeller and tail loads could be transferred to the other. The total weight of the installation would be about 500 lb., i.e., less than 1 per cent. of the all-up weight, of which the alternators weighed 180 lb. They concluded that the thermal energy requirements for an electrical de-icing system might range from $\frac{1}{5}$ to $\frac{1}{10}$ of those for a hot-gas anti-icing system.

Flight Instruments.

The development of flight instruments and automatic pilots over the past 50 years was reviewed in a paper entitled "The Control of Flight," by Mr. Preston R. Bassett. The only instrument required by the pioneer of aviation, he said, was an engine-r.p.m. indicator. As soon as higher altitudes were attained, however, an instrument for measuring height—the aneroid barometer calibrated in feet—became necessary. This was followed by a pitot tube and pressure gauge for measuring airspeed. For navigation, a magnetic compass was added; the simple magnetic compass, however, required to be balanced against the vertical component of the earth's field, and the resulting acceleration when the aircraft changed course made the compass indications erratic. It had now been superseded by some form of flux valve such as the Gyrosyn, which had no rotating magnetic element.

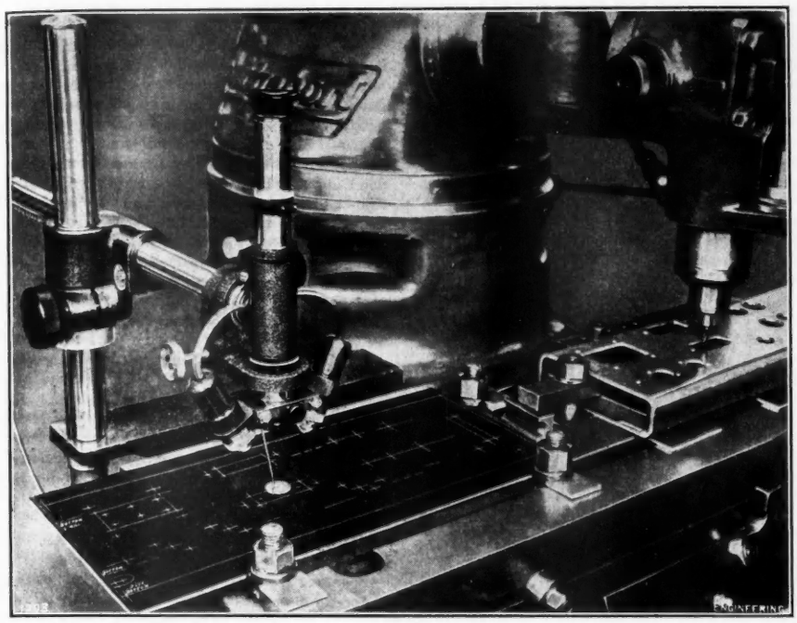
The first step in the development of instruments for allowing control of the aeroplane without visibility was the Sperry gyroscopic turn indicator, in 1918, developed in the first place to supplement the magnetic compass; by flying a straight course by the turn indicator, the compass would settle down and a reading could be taken. It soon came to be the basic blind-flying aid. About the same time, a rate-of-climb indicator, developed from the bubble statoscope of balloonists, was introduced. A banking indicator, consisting of a ball in a curved glass tube, was added to the turn indicator. During the early 1920's, with these instruments, blind flying became a possibility, but the rapid integration of the separate instrument indications imposed a difficult task on the pilot.

In 1928, the introduction of the gyro horizon and the directional gyro, which indicated angular displacement directly instead of by rates, greatly simplified the pilot's problem of interpretation. With longer range aircraft, however, new problems of fatigue, navigation, communication, and traffic arose. The application of the gyroscope to stabilising aircraft was first carried out by Sperry in 1912, but it was not until 1933 that it was considered seriously for large transport aircraft, in the form of a system of air-driven gyroscopes, pneumatic signals to hydraulic control valves, and piston-operated power units. The application of electronics to automatic pilots, from 1938, made it possible to add properly proportioned rate signals to the displacement signals, improving damping control and making possible the greater precision demanded by high-speed flight.

By the late 1930's, instrument panels had become complicated, and no two were alike; attempts, mostly unsuccessful, were made to combine the indications. During the second World War, a trend towards the standardisation of instrument markings and panel arrangements became apparent. Recently, the American air transport industry and the Civil Aeronautics Board had approved a standard instrument panel layout. From studies on instrument approach carried out over the past eight years, the Sperry Zero Reader had been developed. This instrument, instead of indicating to the pilot the altitude or movement of

OPTICAL FOLLOWER FOR MILLING MACHINES.

SALISBURY PRECISION ENGINEERING, LTD., SALISBURY.



the aircraft, directed him how to move his controls to perform some predetermined task. It consisted of vertical and horizontal pointers which he had to keep central. In the case of an approach, for example, the compass heading, position with respect to the localiser path, angle of bank, angle of glide, and position with respect to the glide path, were fed into the Zero Reader computer, which displayed the answers as deflections of the crossed pointers. The latter responded without time lag to the pilot's correcting movements.

The success of a landing approach depended on the weather and the accuracy with which it was reported to the pilot, the electronic navigational and visual aids at the airport, and the aircraft's instrumentation and its coupling to the navigational aids. Tests had shown that a much better approach performance was obtained when the pilot was directed by an instrument such as the Zero Reader, or under completely automatic control, than under manual control with standard flight instruments only, because the two former methods guaranteed that the altitude, direction and position of the aircraft were correct when visual contact was made with the runway. Adequate vision of the runway was principally a function of the horizontal or slant visibility range. Approach lights, runway lights and distinctive runway markings were essential aids to the transition from instrument to visual contact, and so were good weather reports. Present weather reports were not sufficiently accurate either in time or location.

A development which held great future possibilities was the use of pictorial map indicators, in which the aircraft course was plotted by pen on a map. The introduction of airborne commercial radar for cloud warning was overdue.

(To be continued.)

ADHESIVE FOR LAGGING.—The Arabol Manufacturing Co., Ltd., 146A, Queen Victoria-street, London, E.C.4, announce that the American "Arabol" lagging adhesive is now being made in this country. It is used to fix the covering over ordinary lagging, and is quicker than the sewing method. In addition, because it is a synthetic resin, it is waterproof and can be used out of doors, or even under water. It has certain advantages in fire resistance as the canvas can be burnt away leaving the adhesive holding the insulation in place. The resin is repellant to rodents and insects, so that the canvas is not attacked by them. Mechanical strength and abrasion resistance are said to be high.

OPTICAL FOLLOWER FOR USE WITH MILLING MACHINES.

MACHINES such as jig-borers are usually very much in demand in the toolrooms that are fortunate enough to be equipped with them. The photograph reproduced above shows the Boeckeler optical follower, which has been introduced by Salisbury Precision Engineering, Limited, Old Sarum Works, Castle-road, Salisbury. It has been designed for use with vertical and universal milling machines, and enables them to carry out a number of tasks that would normally have to be done on a jig-borer. The bracket which supports the follower bolts on to the knee of the machine and the method of adjustment employed enables settings to an accuracy of 0·0001 in. to be obtained.

The main feature of the follower is the microscope, which has a Ramsden eyepiece and an achromatic objective of high resolving power to give a magnification of × 32. The field is 3·3 mm. and the cross-hairs, which are placed at 90 deg., can be rotated independently of the microscope body. Placed either side of the microscope are two 6·75-watt lamps using alternating current; the junction box, etc., are mounted on the support immediately behind. Both lights are arranged to illuminate the area directly beneath the cross-hairs. The objective lens of the microscope is fitted with a steel ring from which a wire extends. This is provided to assist in locating the microscope body over the point to be determined prior to the actual sighting. Incorporated in the body tubes is a rack and pinion to give vertical adjustment above the template and focusing. The horizontal arm also has a rack and pinion adjustment and lateral motion of the microscope body is provided by an adjusting screw. In addition to these adjusting arrangements for three-dimensional setting, provision is made for fine setting over the template. The cross arm can be raised or lowered on the supporting pillar 9 in. and swung around in a maximum arc of 15 in. radius.

The whole unit is supported by a bracket made from bright finished steel welded together, and the supporting pillar and cross-arm have a chromium-plate finish. The cross-arm is hollow and carries the electric lead to the junction box. It is suggested that the bracket be held to the knee of the milling machine by two ⅜-in. socket-head cap screws.

The principle on which the follower operates is visual spotting and following of a template for duplication on the component. The illustration shows the follower in use with a plate which involves 54 separate locations. The template may be steel, aluminised glass or other suitable material, and marked out in the normal manner with a height gauge or other form of marker. As can be seen in the illustration, the template is securely clamped to the work table after being adjusted for truth of indication. When setting up, the component and template are arranged in alignment with each other. The spindle of the miller is then located over a convenient point on the component—a corner edge or marked point. After this the follower is independently adjusted over the corresponding point on the template and locked in position. The table of the machine is then free to be moved about, each point to be machined being located on the template with the aid of the follower before machining; because the follower is attached to the knee of the miller the focus is kept intact even though the knee may be raised and lowered. Tools and chucks on the milling head can also be changed for different operations without affecting the setting of the template, component and focus of the follower.

The makers point out that with an optical instrument of this nature there is no chance of being off-centre by one turn of the lead screw, as is sometimes the case with a jig-borer, nor is back-lash a factor in setting. They also state that it is possible to reset from one hole to the next in 15 seconds and retain an accuracy of 0·0002 in.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(Continued from page 404.)

WE continue below our report of the Autumn Meeting of the Institution of Naval Architects, held in Holland from September 14 to 19. Last week's issue recorded the opening events, summarised Professor van Lammeren's paper on recent research work at the Wageningen ship-model tank, and contained also the remarks of the first two speakers in the discussion which followed it.

Professor A. F. Lindblad, continuing the discussion, observed that Professor van Lammeren had compared the performance of his models with those of the "standard series"; which, presumably, meant the Taylor series. That, however, was not a very good comparison at the present time, because much better forms had been developed for ships of low speed. With reference to propellers, the paper stated that only designers with extensive experience could apply the theory, and correction factors, in such a way as to ensure good results; and later the author mentioned that some of the factors had been submitted to the Mathematical Centre for a detailed perusal, on account of the observed discrepancies. That was rather discouraging, because those factors did help the naval architect, who seldom had time to go deeply into theoretical mathematics. At the end of the paper, the author stated that it was of great importance to collect carefully and systematically, and to analyse, the greatest possible number of trial-trip and service results of ships; and that was being done under the guidance of Professor Bonebakker, of the Technical University at Delft. Therein lay the hope of achieving correlation between model and ships; the work indicated would certainly help in that direction.

Mr. K. G. Evans noted with interest that Dr. van Lammeren was tackling the problem of relating the results of open-water tests on propellers with those obtained in the cavitation tunnel. The method he proposed to obtain the wall correction was direct, but if the experimental rig was on the scale shown in the paper it seemed likely that the velocity field of the boat would cause a significant non-uniform flow at the propeller. An investigation was carried out on the wake forward of the shroud supporting the dynamometer in the case of the open-water propeller experiments described by Dr. Gawn at the Spring Meeting. The calculation suggested that the wake induced by the shroud in the plane of the propeller would vary from 0·69 to

0·83 on the vertical through the propeller axis and somewhat less for the whole disc area—between ½ and ¾ per cent.—which was confirmed by Pitot-tube tests. Comparing Dr. Gawn's paper with that of Professor van Lammeren, the dimensions of the boat were relatively much larger than the shroud, so that the induced wake might be expected to be a few per cent.—of the same order as the wall correction to be measured.

With regard to propeller theory, most would agree that hollow-face sections with a rounded leading edge offered the widest safeguard against cavitation in a variable wake; but the gains in propulsive efficiency by using such sections were slight, at all except very high speeds. The benefit resulted from the reduced cavitation, and consequently reduced erosion damage and vibration. The author did not mention the United States National Advisory Council on Aeronautics, whose report, "Summary of Aerofoil Data," published in 1945, was of particular interest to propeller designers. He would appreciate the author's views in more detail on camber and shape of sections, and endorsed his doubts on the accuracy of the published figures for camber correction; it had been their experience at Haslar that these were generally too low. A propeller of very large area, having a blade-area ratio of 1·1, which was designed from theory several years ago, was 8 per cent. low in pitch. Since then, they had evolved a fairly successful procedure for design which used the pitch-correction technique given by Dr. H. W. Lerbs in his 1952 paper before the Society of Naval Architects and Marine Engineers and also incorporated an arbitrary increase in camber correction, based on experience derived from propulsion tests on 12-in. diameter models in the cavitation tunnel.

Dr. H. W. Lerbs said that he would restrict his remarks to the fundamentals of propeller theory, and the reasons why he was inclined to consider the induction factors as the functions of primary importance in propeller theory, which should be established with the greatest possible accuracy. He would also mention two applications of the theory, namely, to the "wake-adapted" propeller and to contra-rotating propellers. Much valuable work on the wake-adapted propeller had been done by the Netherlands Model Basin in recent years. The work at the Taylor Model Basin aimed at establishing the minimum energy loss condition on a basis of the induction factors. The application of those factors instead of the Goldstein function was necessary, since the free vortex sheets differed from the true helical shape. The analysis yielded an integral equation for the optimum circulation distribution; but the assumption of axis-symmetrical inflow was implied, and it must be shown that the peripheral non-uniformity of the wake was of minor influence on the optimum circulation distribution. This led to a problem of unsteady flow, with which additional losses of kinetic energy were associated. Neglect of the peripheral non-uniformity was justifiable when the non-steady flow losses were small as compared with the power input. For an arbitrarily-given wake field, the result was obtained that the losses associated with non-steady flow were proportional to the number of blades, to the chord length and to the square of the amplitudes of the harmonics of the wake. For an actual case, that loss was about 1 per cent. of the power input.

He was greatly interested in the author's reference to contra-rotating propellers. Some analytical work was being done on that problem at the Taylor Model Basin—again on the basis of induction factors. To establish the mutual interference of the propellers, the induced velocities must be known, not only at the blades, but also between them. That necessitated an extensive evaluation of Biot-Savart integrals, which was being done by means of the electronic calculator. He would be interested to learn how the Netherlands Model Basin had attacked that problem. There was justification for saying that methods for treating the practically important propeller problems on a rational basis were progressing; and that the Netherlands Model Basin would play an important part in the future development of the work.

Professor E. V. Telfer said that, comparing the texts and subjects of the papers presented at the meeting with those presented when the Institution met in Holland in 1923, there was one outstanding difference, namely, the present-day accent on research. Thirty years ago there was no Wageningen tank, and he was confident that the idea that Wageningen should have a tank was somewhat assisted by their 1923 visit to Holland, and by the Dutch Institute. There was one point of a technical nature that he would make: he did not like so much emphasis on the Karman-Trefftz section or even the Walchner section, because none of those investigators had first-hand contact with the actual design of propellers. Full credit should be given to the late Sir John I. Thornycroft for the design of what was now called the hollow-faced section, which was merely a section with increasing axial pitch and was the equivalent of the Karman-Trefftz section; that type was the successful propeller in the original Daring experiments. It would be interesting if now, so many years afterwards, they could have a detailed plan of that earlier propeller, in order to see how much was really known 30 years ago about the most efficient way in which to overcome the cavitation problem. He was sure that Professor van Lammeren would like to see what was done, and would admit that those who were working first in the field were not altogether in doubt as to what the ultimate cure for that problem would be.

Dr. G. C. Manning made a plea for the use of non-dimensional coefficients in reporting the results of research, for he thought that the advantages accruing from their use extended beyond the fact that they had the same value in metric units as in English units; fundamentally, they afforded a better understanding of the value of the results quoted.

Dr. F. H. Todd said that, in 1951, in Washington, Dr. Livingstone Smith, of the British Shipbuilding Research Association, gave a detailed account of the research programme then in hand in Great Britain; now they had the programme that had been carried out at the Wageningen tank. On the following day, he hoped to present a similar outline of the programme of the United States Navy in the field of hydromechanics. He wanted to bring the three together, because they showed how much was being done in hydromechanics research: a field which, he felt, had been considerably neglected by comparison with that of aeronautics. With regard to the measurement of the resistance of the model discussed in the paper, other speakers had already made the point that the model might be influenced by the wake of the towing ship. In the United States, they had measured the propeller thrust on a large number of warships, and hence had obtained the resistance of the ships in the most direct way by making one assumption, namely, that the thrust deduction factor measured on the model also applied to the actual ship. At no time, to his knowledge, had they ever measured a full-scale thrust deduction factor. That necessitated measuring the full-scale thrust and the full-scale resistance; if those could be measured on a number of ships and some confidence gained from the fact that the model thrust deduction could be applied to the ship, they would have confidence also to use a greater number of trials to obtain the roughness coefficient.

Mr. V. G. Shepheard, referring to a point raised by Professor Telfer, said that he was not sure whether information about the early Daring propellers was still available, but if they were, he would include them in the discussion. It was a coincidence that recently they had been carrying out a series of tests, on the new Daring class, of different types of propellers. They had also made tests on another destroyer, with propellers of varying blade shape and blade areas; thereby they expected to gain a lot of information under full-speed ship conditions and also at cruising speed, which should be very valuable. In the fullness of time, perhaps Dr. Gawn would be able to present a paper on it.

Professor L. C. Burrill, after praising the work being done at Wageningen, said that, while the excellent technique followed in the D. C. Endert, Jr., would provide full data concerning a vessel 70 ft. long, he might mention that tests were made on a 47 ft. 6 in. model of the Cunard liner Mauretania* as early as 1906. They were carried in out the Northumberland Dock, near Newcastle, but unfortunately the results were buried in the archives of the builders, Messrs. Swan, Hunter and Wigham Richardson, Limited, and no one other than those in that company had seen them since. To-day, the results of such work would be published immediately, and naval architects throughout the world could use them practically.

In Fig. 1 of his paper, Professor van Lammeren gave a CE curve showing a non-dimensional coefficient in terms of shaft horse-power; it might be better if workers in Holland would use the term D.H.P., which Taylor introduced, meaning the definite power delivered to the screw. He suspected that the author's S.H.P. was, in fact, D.H.P. About the so-called Karman-Trefftz sections, Professor Burrill continued, he had been aware of the design and fitting of propellers with hollow-faced sections for some 15 or 20 years, but it was not until he visited the Wageningen tank three or four years ago that he discovered there were such things as "Karman-Trefftz sections." There was no difference, he thought, between sections having circular-arc definition of the back and face, and a Karman-Trefftz section; he felt, therefore, that it was misleading when a name such as Karman-Trefftz was given to them. Experience with the Karman-Trefftz or hollow-faced section had been mixed; he had known propellers to be altered from flat-faced to hollow-faced sections and then to develop cavitation erosion on the face side, with other deleterious effects. He was sure that Professor van Lammeren was aware of that.

Professor van Lammeren did not reply verbally to the discussion, owing to the limitation of time.

* Described and illustrated in ENGINEERING of November 8, 1907 (vol. 84, page 611).

Presentation of Honorary Membership to Prince Bernhard.

On the same morning (September 15) the Institution was honoured by a visit of H.R.H. The Prince of the Netherlands, Inspector-General of the Royal Netherlands Navy, to receive the diploma of Honorary Membership of the Institution. His Royal Highness was escorted to the dais by the President, who, in presenting the diploma, mentioned that the Honorary Members of the Institution were "a small, but, I hope, reasonably select band," no more than eight in number, but including the King of Denmark, Sir Winston Churchill, and one who was present at the meeting, Sir Thomas Havelock.

"We ask you to accept our Honorary Membership," Lord Runciman continued, "not primarily for any technical knowledge of naval architecture which you may possess, for I understand, Sir, that, distinguished as your technical achievements are, they are confined to rather lighter elements. In that, too, you will find yourself not alone in this company, for there are those here who have at one time or another done service in the air; service, however, which has not prevented them coming back again to the heavier and perhaps slower element with which they started. There is, indeed, a very considerable connection between the air and the sea; it came out only this morning in our discussion that there is still a great deal which each of us can learn from the other. We are grateful to you because, in accepting our Honorary Membership, you allow us to express through you our appreciation of, and respect for, the naval architecture and the shipbuilding of the Netherlands. There have been times in the past when, I think, we in Great Britain might have wished that the Netherlands' achievements in this direction were not quite so efficient. Now, however, we are able to work very closely together, both in naval and commercial affairs. In that sense, therefore, and with a very strong feeling of respect for the achievements of the Netherlands in naval architecture, I ask you to accept this scroll of Honorary Membership of the Institution of Naval Architects."

His Royal Highness, in reply, said that he felt greatly honoured by the offer of Honorary Membership of the Institution of Naval Architects, and was glad to accept it on behalf of the naval architects of the Netherlands.

(To be continued.)

THE NEW METAL TITANIUM.*

By DR. MAURICE COOK.

DURING the past six or seven years or so, an enormous amount of scientific and technological work has been carried out on titanium, mostly in the U.S.A., but not only there. On work of this kind many millions of pounds have been spent, and not only is the effort still proceeding, but it is being intensified. Never before has there been in so short a time so much research activity directed to a single industrial metal.

Clearly there must be a reason and a justification for this, and indeed there is. Briefly, it is that the metal has attractive physical and mechanical properties, a high strength-to-weight ratio, and outstandingly good resistance to corrosion generally. Its importance as a very desirable if not uniquely suitable material for several aircraft components was recognised as soon as sufficient of it had been made to enable its properties to be determined, if only approximately, and for evolution tests to be made. Much of this work was done on metal compacted from powder before techniques for melting in quantity were devised and developed.

Although its current production runs to an annual level of a few thousand tons, the use of titanium, because of its price, is limited at present for special purposes. This indeed may long continue to be the position. On the other hand, if more convenient and cheaper methods of extraction were devised, so enabling its cost to be very substantially reduced, then it might well become a large-tonnage basic metal. In these days of high metal consumption which have witnessed temporary shortages, unbalances, and high costs among some of the older strategic materials, as well as uncertainties regarding the future availability of some of them, the advent of a new metal is a matter of no little interest and moment. Especially is this so when it is known that the metal and its alloys possess properties which make them not only attractive for special uses, but suitable also for ordinary and more general applications involving large tonnage consumption.

It is, however, a far cry from the present position of expensive production and processing to what still is the purely imaginative one of manufacture at price levels even approaching those of the more costly basic metals. All the major problems connected with the extraction, melting, and fabrication of titanium, and there are indeed many, stem from its very high degree of reactivity when hot and particularly when it is molten. Its great affinity for oxygen, the extremely low free energy of its lower oxides, the solubility of oxygen, and the marked embrittling effect which quite small traces of it have on the metal, have proved major obstacles in the production of titanium of satisfactory quality by direct reduction of its oxide, and in the reduction processes so far developed and worked industrially it has been found necessary to start with oxygen-free compounds. Since the molten metal attacks all the known refractory materials used for lining metal-melting furnaces and for making crucibles, because of the solubility of nitrogen and oxygen in titanium, and to a lesser extent because of its high melting point, which is at present accepted as 1,725 deg. C., special equipment and procedures involving melting *in vacuo* or in argon, far more costly to operate than the techniques usually employed for melting other metals, have had to be developed.

PROPERTIES.

Titanium undergoes an allotropic transformation at 882 deg. C., above which temperature it has a body-centred cubic structure, known as the β phase, and below this temperature it has an hexagonal close-packed structure, known as the α phase. Pure titanium, such as that produced by the dissociation of titanium tetraiodide, is a relatively soft metal with high ductility.

High-purity titanium can be easily cold worked, and it can sustain deformation to the extent of reductions in area of more than 95 per cent. before annealing becomes necessary for further working. Its ultimate tensile strength is, however, only of the order of 15 tons per square inch, with an elongation value, on 2 in., of between 40 and 60 per cent., and, therefore, as an engineering material or as a constructional metal in a wider and more general sense, its possibilities are not comparable with those of commercial grades of titanium or of titanium alloys.

Commercially pure titanium as produced by chemical reduction methods has considerably greater strength and lower ductility than titanium produced by the iodide-dissociation method, although the crystallographic features of the deformation mechanism are maintained. Ultimate tensile strength values of about 35 to 40 tons per square inch, with 30-25 per cent. elongation, are typical of this quality of metal. The marked difference between these properties and those of the iodide metal is attributable to the presence of impurities, some of which in titanium have effects of unusual magnitude. Indeed, the technology of titanium is dominated by four impurities—oxygen, nitrogen, hydrogen and carbon—all of which form interstitial solid solutions up to the limits of their solid solubilities. They find their way into the metal at various stages of processing, and, in fact, most of the major problems arising in the production, melting, and subsequent working of the metal are associated with the necessity for excluding, or at least minimising as far as possible, contamination by these impurities. So far as production technology is concerned, oxygen is, so to speak, in the light of present knowledge, titanium enemy number one, with nitrogen quite well behind in second place. Although their effects on processing and properties are pronounced, hydrogen and carbon are less significant impurities, since the former can be removed from the metal without recourse to remelting by heating to 800 to 1,000 deg. C. *in vacuo*, while contamination by the latter can be limited to tolerable proportions by effective control of the purity of raw materials and melting conditions.

Commercially pure titanium can be readily hot worked by forging, rolling, extrusion, and other conventional methods, but in general, it is more resistant to cold working than are most non-ferrous alloys usually produced in wrought forms. One feature of titanium which adds seriously to the difficulty of such cold-working operations as drawing of various kinds and deep pressing, is its unfortunate tendency to seize on other metals during sliding contact with them under pressure. So far no lubricant has been found which will prevent seizure of metal-to-metal surfaces, but this can be overcome to some extent through avoiding metal-to-metal contact by oxidising the surface of the titanium or depositing on to it layers of other substances to serve as vehicles for the lubricant. Even under these conditions, only highly viscous or semi-solid lubricants can be used with any measure of success. Thus, for example, in drawing wire or tubes the metal surface can be oxidised and then carefully coated with molybdenum disulphide or a mixture of soap and calcium stearate. Alternatively, where circumstances necessitate it, recourse can be made to the technique of sheathing with another metal, which is removed by pickling towards the end of the cold-working operations.

In addition to the need for minimising contamination in processing and for special techniques for drawing, such as those just referred to, another factor which looms large, if indeed not largest, in the economics of current wrought-titanium production, is that scrap metal cannot be remelted and returned to the production cycle. This arises partly from the fact that massive scrap cannot be fed into arc furnaces of the type at present employed for melting titanium, and partly from the necessity of avoiding cumulative contamination which would result from repeated melting and fabrication. Considerable effort is therefore being directed towards developing furnaces capable of melting scrap in the charge and in devising processes for the removal of at least some of the contamination before remelting.

The fatigue properties of titanium are unlike those of most non-ferrous metals for the S/N curve shows an approach to a true fatigue limit. The ratio of fatigue to tensile strength is generally greater than 0·5, but the most notable feature in which titanium excells other non-ferrous and ferrous alloys in respect of fatigue-resistance is the degree to which this ratio is maintained under corrosive conditions. The impact strength of commercially pure titanium is of the order of 20 to 25 ft.-lb., and while this property is very susceptible to the presence of impurities, notably hydrogen, very much higher values characterise the pure metal.

Even at room temperature the creep properties are disappointing, and tests which have been carried out so far indicate that creep occurs when the metal is stressed near to its proof stress, which is unusual in a metal having so high a melting point. Despite the expectations there may have been in view of its high melting point, commercially pure titanium is not suitable for applications involving long-continued stresses at temperatures exceeding 350 deg. C.

Joining presents numerous problems, many of which, especially those concerned with brazing and soldering and with the welding of alloys, are not yet solved. Commercially pure titanium can, however, be readily welded by electrical resistance methods, and also by means of argon-arc techniques, provided that precautions are taken to shield from atmospheric contamination not only the molten welded metal, but also all heated parts of the base metal, including the back of the weld. In the welding operation the metal runs easily, and there is no difficulty in consistently producing sound ductile welds of good appearance.

The attractive strength : weight ratio is the feature of titanium and its alloys chiefly responsible for their demand and use in aircraft, but the other excelling characteristic of the metal is its resistance to corrosion. The early optimism about this has been abundantly justified. In a series of tests in which titanium and austenitic stainless steel impellers were rotated for periods of up to 500 hours in 40 per cent. boiling cupric chloride, cold *aqua regia*, boiling concentrated nitric acid, and heavily polluted sea-water containing erosive silt, it was found that while the titanium was practically unaffected after the full period, the stainless-steel specimens were all seriously corroded, some after much shorter periods of time.

This outstanding resistance to corrosion is attributed to the presence of a protective oxide film which is most stable in oxidising environments, and under such conditions the behaviour of the metal is similar to that of stainless steel, but additionally the film on titanium is resistant to penetration by the chlorine ion, and so the metal is resistant to moist chlorine and aqueous solutions of many chlorine-containing compounds. Its resistance to sea-water and to marine conditions generally is of a very high order indeed. Furthermore, it is not corroded by fouling organisms in sea-water, nor is it corroded in this medium when it is coupled, for example, to stainless steel or cupro-nickel.

It is resistant to cold nitric acid up to 98 per cent. concentration, sulphur compounds, strong alkalies, many organic acids, chlorinated solvents, and cold *aqua regia*. It is not affected by most foods and food products, or by body fluids, and being non-toxic it could be used for many purposes in surgery. In those solutions which do attack the metal, such as certain hot strong acids, the corrosion always appears to be general without evidence of either preferential intercrystalline or stress corrosion.

TITANIUM ALLOYS.

The role which various alloying elements play is becoming more clearly defined. It is possible in this regard to classify them into several groups on the basis of relative solubility in the two phases, but in considering them more generally and broadly it has been established that most of the metallic elements so far investigated, including iron, chromium, manganese, molybdenum, vanadium, tantalum, and niobium, depress the transformation, are more soluble in the β phase than in the α phase, and tend to stabilise it. Two metals, namely, aluminium and tin, have just the opposite effect. They are more soluble in the α phase, with which they form sub-

* Twenty-fourth Autumn Lecture delivered before the Institute of Metals, at Southport on Monday, September 21, 1953. Abridged.

stitutional solid solutions, tend to stabilise it, and raise the transformation. Other elements, such as oxygen, nitrogen, carbon, and boron, which form interstitial solid solutions have the same effect.

As a result of alloying, the superlatively good corrosion-resistance of the metal does not appear to be impaired, and, in general, the alloys possess the excellent fatigue and corrosion-fatigue properties that characterise the metal. Impact-strength values range from about 5 to 15 ft.-lb., according to composition, grain-size, structure, and impurity content, and although these are relatively low, they increase rapidly with temperature, values of 100 ft.-lb. being obtained with titanium-chromium-iron alloys with temperatures over 250 deg. C., while alloys have been produced experimentally with room-temperature impact strengths of over 50 ft.-lb. Although some doubt has been expressed concerning the notch sensitivity of high-strength titanium alloys, particularly when subjected to fluctuating stresses, recent evidence suggests that some at least of the duplex alloys are equal to or better than high-tensile steels in this respect.

CHEMICAL RESEARCH LABORATORY.

During the open days held last week at the Chemical Research Laboratory, Teddington, a wide range of interesting exhibits was on show. Six main research groups are working there: Corrosion of metals; Inorganic; Microbiology; Organic; High Polymers; and Radiochemical. Probably the one dealing with metallic corrosion holds most interest for engineers, although the extraction of metals in both the inorganic and radiochemical groups is of some importance.

In the corrosion section, new work is being undertaken on the high-temperature corrosion of steels. This has, for its immediate object, the study of corrosion in boiler superheater tubes. Specimens are immersed in a flue-gas atmosphere and held at temperatures between 500 deg. and 600 deg. C. for the required time. A balance fitted over the top of the furnace enables the weight increase to be measured during the course of the experiment. At present, only correlation work is being done in conjunction with other laboratories in order to set up test standards. The research is being carried out in conjunction with the British Iron and Steel Research Association and the Electrical Research Association. Work continues on phosphate coatings and, although no definite conclusions can yet be given, it is evident that the surface treatment prior to coating has a very large effect on the protection. A series of photographs was shown illustrating this. There is much work being done on corrosion inhibitors in general, both for outdoor conditions and for packaging. Potassium chromate was being used as a surface protection with radioactive chromium to show the penetration and life of the protective coating. The water uptake of painted steels was being measured by the change in capacitance of the specimen. Underground corrosion and its causes and prevention is the subject of a large section. Corrosion is found to be worse in the presence of the sulphate-reducing bacteria *desulphovibrio desulphuricans*, frequently present in damp soil. The action of these bacteria is inhibited by the presence of tannin and some other substances. Examples of well-preserved ancient iron from a site at Hungate, where there had formerly been a tannery, were shown. Work is also being carried out on these bacteria by the Microbiological Group, and examples were shown of the bacteria themselves and of their action.

For packaging, impregnated papers are being investigated as well as vapour-phase inhibitors. Papers treated with sodium benzoate are effective for steel but not so good for cast-iron or zinc. Various thixotropic pastes are also being tried. The "Weatherometer" continues in use to give accelerated weathering tests with water sprays and ultra-violet and infra-red radiations. The four model boilers used for studying boiler-tube corrosion on behalf of the British Shipbuilding Research Association are still in service. This work, as well as other corrosion work of the Laboratory, is the subject of a leading article on page 434. The effects of high- and low-speed movement of metal in various solutions are also still being studied. A search for rare elements in waste products is being carried out by the Inorganic Group in the Hales building. Selenium, gallium and germanium are the metals particularly concerned. The demand for these has grown considerably recently and all sources are being investigated. Various processes for their extraction were illustrated. A collection of specimens of pure metals was also shown.

The Radiochemical Group were exhibiting many interesting processes, among them was an ore treatment for metal extraction. There were a magnetic separator and a small crushing and screening plant. Some ingenious mechanisms were being used in the continuous processes, among them a Sigmund "rolling finger" pump for pumping liquid through rubber tubing and an automatic fraction collector, operated by a photo-electric device, which removed collecting bottles after an exact volume had entered them, and replaced them with empty ones.

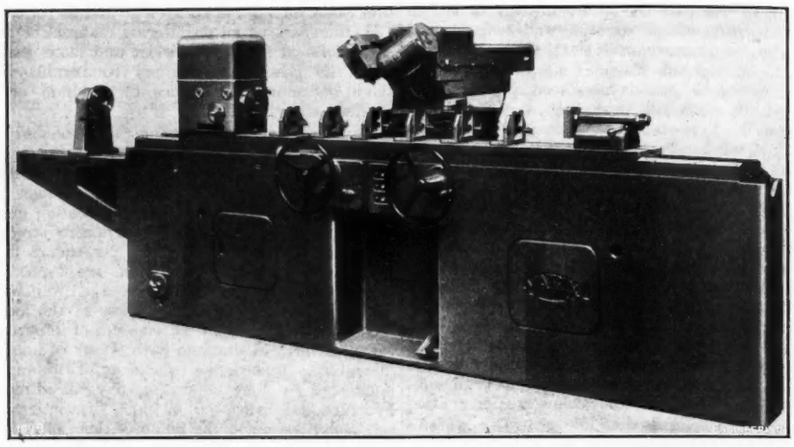
Short Courses on Electrical Engineering.—Five short courses on engineering subjects (consisting of from two to four weekly lectures) are to be held at the South East London Technical College, Lewisham-way, London, S.E.4, during the present session. The subjects are "Bessel Functions and Their Applications"; "M.K.S. System Applied to Engineering"; "Wide Band Carrier Systems"; "Variable Speed A.C. Motors"; and "Leakage Reactance and Magnetisation Transients." The courses commence during the latter half of November.

Couplings for Rigid and Flexible Conduit.—A sleeve coupling known as the "Abcon" is now being made by Abboflex, Ltd., Ferry-road, Teddington, Middlesex, for joining rigid or flexible metallic conduit. The firm also manufacture "Abconflex" flexible conduit which has the same outside diameter as rigid conduit. The sleeve can be slid over the ends to be joined, and is then clamped in place by nuts running on taper threads at each end of it. It gives good bonding, avoids screwing the conduit and can be removed and replaced without disturbing the run.

Commonwealth Conference on Aeronautics Research.—At the third meeting of the Commonwealth Advisory Aeronautical Research Council in London, which was opened on August 31 by Sir John Cockcroft and which ended on September 19, the subjects under discussion included new problems arising from high-speed flight, and the possibility of providing a Commonwealth pool of aircraft for flight research; new materials; the aerodynamic efficiency of water-based aircraft; engineering problems of conditioning aircraft for human occupation and control; aircraft noise; and the importance of Commonwealth co-operation in studying gusts at high altitudes. The conference chairman was Professor A. G. Pugsley; delegates from Australia, New Zealand, Canada, India and the United Kingdom were present.

BROACH-SHARPENING MACHINE.

COVENTRY GAUGE AND TOOL CO., LTD., COVENTRY.



BROACH-SHARPENING MACHINE.

The Coventry Gauge and Tool Company, Limited, Coventry, are now manufacturing a broach-sharpening machine which will take round broaches up to 4 in. diameter and has a length between centres of 72 in. Known as type 54, it is made in three models: for round broaches only and manually operated; for round or flat broaches and manually operated; and for round or flat broaches and hydraulically operated. The illustration shows the latter model, but in general the three are similar.

The main work-slide of the machine is operated by the handwheel on the left. It has a total travel of 90 in. On it are mounted both the headstock and the tailstock, together with the clamps or magnetic chuck for holding the work. The headstock and tailstock are each held by one bolt only for easy removal when flat broaches are to be ground. In the headstock is a driving motor of 0·6 h.p., giving work speeds of either 250 or 500 r.p.m. The work spindle can also be rotated by hand. The driving plate is 7½ in. in diameter and is indexed for 2, 3, 4 and 6 divisions for sharpening broaches with two or more sides. The tailstock can be adjusted 1 in. in height to allow for the taper of the broach. The vertical slide carrying the grinding head, which has a movement of 9 in. above centres, is controlled by the hand-wheel on the right. This has a dial marked in divisions of 0·001 in. The vertical slide is balanced and contains the hydraulic pump and motor for operating the cross-slide. The latter has a maximum stroke of 4 in. and is mounted on rollers for smooth operation. It can be swivelled up to 45 deg. for grinding shear-cut broaches. The rate of traverse is controlled by the pedal in the recess. Stops can be adjusted to give the required travel.

The grinding unit is clamped to the cross-slide so that it can be tilted at any angle up to 60 deg. The motor is 0·8 h.p., driving the grinding wheel directly at 2,840 r.p.m. Wheels of 2 in., and with an adaptor 4 in., or 8 in. diameter can be fitted. For small broaches a high-speed unit can be attached which will drive 1-in. or 2-in. diameter wheels at 8,000 r.p.m. There is a profile wheel-dresser for 8-in. diameter wheels, but smaller sizes are dressed by hand. At the extreme left of the illustration can be seen the attachment for grinding helical broaches. A leader-bar, of the same lead as the broach, passes through a nut held in the head and engages with the work spindle in the headstock. The belt is removed from the work motor, and the slide traversed either by the handwheel, for fine leads, or by a hand lever on the square shaft in the headstock for coarse leads. A standard index plate for 2, 3, 4 or 6 grooves is provided. The Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, are the distributors for the machines.

LORRY FOR BULK TRANSPORT OF CARBON BLACK.

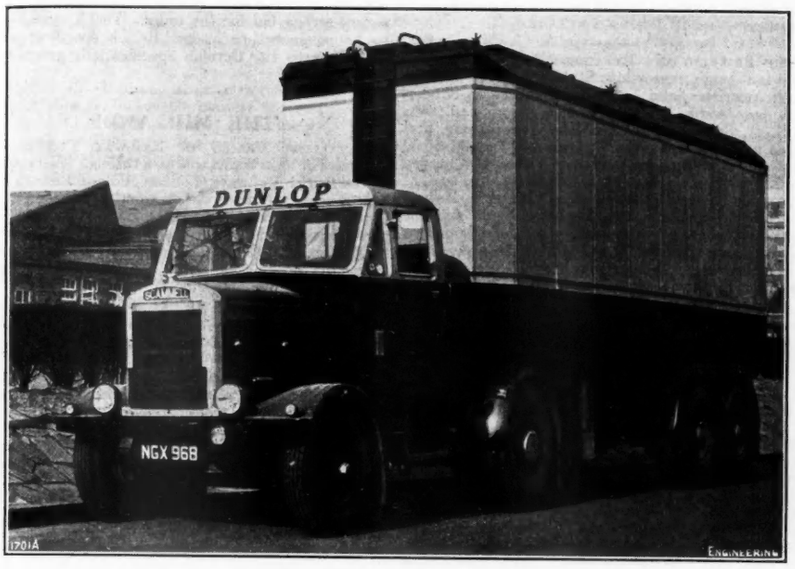


FIG. 1. VEHICLE IN SERVICE.

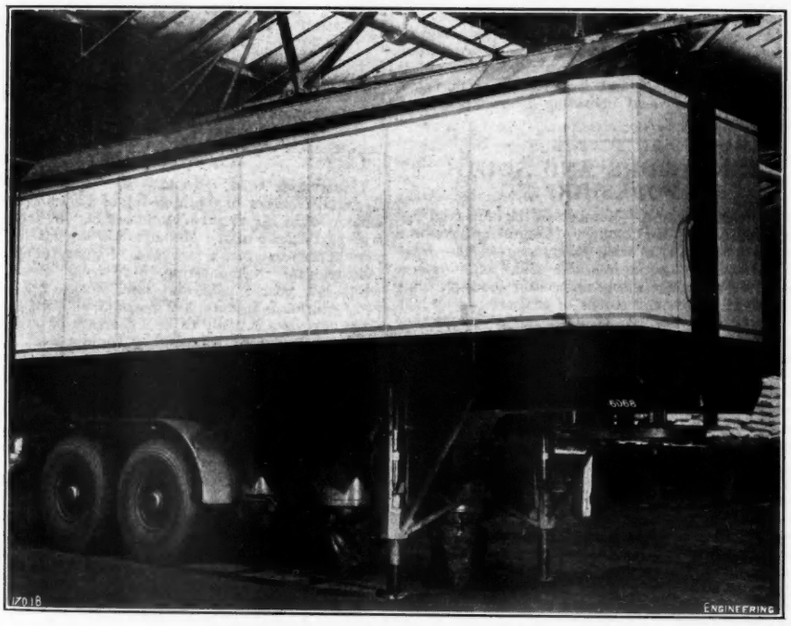


FIG. 2. TRAILER UNIT ARRANGED FOR DISCHARGE.

BULK TRANSPORT OF CARBON BLACK.

THE Dunlop Rubber Company, Limited, have recently brought into service a fleet of road vehicles designed for the bulk transport of carbon black—which is used in the manufacture of motor-vehicle tyres—from the new carbon-black manufacturing plants at Ellesmere Port and Avonmouth, to their tyre factories at Fort Dunlop and Speke. The manufacturing plants are now producing the carbon blacks known as Vulcan 3 and Philblack 0, from imported crude oil, and are thereby saving the country a considerable sum in dollars, which otherwise would be required to purchase carbon blacks manufactured in the United States.

These vehicles have been designed and constructed by Scammell Lorries, Limited, Watford, for the Dunlop Rubber Company, and one is shown in Fig. 1. The vehicle consists of the Scammell motive unit, which is driven by a six-cylinder Gardner Diesel engine, and a trailer unit, which is separately illustrated in Fig. 2. The weight of the motive unit is 4 tons 4 cwt., and that of the trailer, 6 tons 12 cwt., unladen; the carrying capacity of the trailer is 11½ tons, so giving a laden weight for a complete vehicle of 22 to 23 tons. The trailer is of "frameless" construction, i.e., the container itself, which is constructed of mild-steel plate, provides the anchorage to which the trailing bogie is attached. The inner surfaces of the container are made smooth and are rendered with a Valspar varnish in order to ensure that the carbon-black, which is "pelletised" before loading, flows freely through the four discharging hoppers in the lower part of the container. The container is loaded through inlets in the roof. The discharging hoppers have a tapering section with sides at an angle of 60 deg., and each is fitted with a butterfly valve and a hinged cap which can be bolted in its closed position, to prevent the contents escaping during transit.

In Fig. 2, a vehicle is shown discharging at the factory, and it will be observed that flexible sleeves are fitted to guide the contents through the floor and on to the conveyor system below, feeding to the Banbury rubber-mixing machines. The conveyor system is totally enclosed and is provided with a means of dust extraction whereby particles of carbon black suspended in the air are recovered and passed to storage silos. The two jacks which appear in the illustration (Fig. 2) are permanently built in for supporting the forward end of the trailer when the motive unit is detached, and are hydraulically operated.

AN ENGINEERING CENTRE AT BIRMINGHAM.

AN Engineering Centre to serve the light and medium engineering industries is to be established at the Birmingham Iron Exchange. The Exchange was founded in 1861 to help the basic industries of coal, iron and steel by providing a central rendezvous where manufacturers and buyers could meet regularly to carry out their normal business. With the advent of modern business practices, the original function of the Exchange has largely disappeared. In order to maintain, and even to increase, the usefulness of the Exchange, it has been decided to establish, in the reconstructed buildings in Stephenson's-place, a new Engineering Centre.

The Centre will consist of a permanent engineering exhibition and a technical information service designed to keep engineers abreast of the latest engineering developments and to provide contacts between the maker and the consumer. Emphasis will be laid on attracting the overseas representatives; for example, the trade and commercial secretaries from the consulates and representatives of the foreign Press. All British firms producing engineering components or component assemblies will be eligible to exhibit, and space, varying from wall panels to island stands, will be available to approximately 200 firms. The displays will be supplemented by an inquiry service backed by a library of the up-to-date catalogues of over 5,000 firms, directories and reference books, and a register of firms' available manufacturing capacities. Exhibitors will not be expected to provide any staff, all duties being performed by the staff of the Exchange; exhibitors will be required, however, to supply descriptive literature relating to their display.

Accommodation will also be available, in the form of a hall 33 ft. long by 22 ft. wide, for short-term private exhibitions; professional assistance in the organisation and publicity of such an exhibition will be provided if required. Lecture rooms with equipment for film projection, and suitable for either large or small meetings, will be used by trade and technical associations and technical societies, as well as by exhibitors. Copies of over 100 current technical periodicals covering all facets of industry will be displayed in the coffee room. Private offices, with secretarial and telephone services, are to be provided for the use of visitors, agents and representatives.

The Centre, which is to be opened in the new year, will be open throughout the year and no charge will be made for admission. Any surplus monies obtained from the letting of exhibition space will be devoted entirely to enhancing the facilities of the Centre. Inquiries concerning display space should be addressed to the Exhibition Manager, Mr. A. J. COX, The Engineering Centre, Iron Exchange, Stephenson's-place, Birmingham.

ELECTRICITY SUPPLY STATISTICS.—During August, 1953, 3,966 million kWh were sold by the British Electricity Board to the Area Boards, an increase of 9·1 per cent. over the output in the same month of last year. When corrected for the weather and the number of working days, the increase was 9·3 per cent., the conditions having been warmer and there having been more working days than in August, 1952. The amount of electricity sent out by the Area Boards was 8·7 per cent. more than in the corresponding month of the previous year. Supplies to "mainly industrial" areas increased by 8·9 per cent. and to "mainly non-industrial" areas by 8·2 per cent.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Royal Yacht.—The Duke of Edinburgh visited the shipyard of John Brown & Co. (Clydebank), Ltd., on September 21, and made an inspection of the work in progress on the royal yacht Britannia, which has been fitting out since her launch by the Queen on April 16. The yacht is expected to be ready for service within the next few months. The Queen and the Duke will probably be in New Zealand when the Britannia is completed, but they are to join the yacht at Tobruk next May and sail in her via Malta and Gibraltar to London.

Quarry Output to be Raised.—A growing demand for roadstone metal and pre-coated macadam is reflected in extensive programmes for raising output at Cunmont Quarry, Dundee, and Castlehill Quarry, Blairgowrie, both of which were visited recently by the Scottish branch of the Institution of Highway Engineers. The average output of pre-coated macadam at Cunmont during the first eight months of this year was over 6,000 tons a month, but new plant in course of erection will increase the output to about 800 tons a day. A new crushing and screening plant at Castlehill will increase production of sand and gravel there from 100 tons to 250 tons a day.

Finance for Rural Electrification.—The South-East Scotland Electricity Board have announced that they have received 30,000*l.* from the British Electricity Authority to be spent on rural electrification during the present financial year ending on March 31, 1954. They have decided to spend this sum on farms on their waiting lists. The first area to benefit will be Saline, near Dunfermline, and work will begin at once.

Electricity for Tiree.—Mr. Thomas Johnston, chairman of the North of Scotland Hydro-Electric Board, announced at a meeting of residents of Tiree on September 21 that they could expect to have electric light and power in the near future. Earlier, Mr. Johnston and Mr. W. D. Fenton, the Board's secretary, discussed the proposed supply with members of the District Council, and it was stated that the terms and cost of distribution to the consumers had been agreed to. The current will be generated by a Ministry of Civil Aviation's Diesel plant at the island's airport.

CLEVELAND AND THE NORTHERN COUNTIES.

Penrith Electricity Substations.—A substation built at Penrith to improve the supply of electricity in East Cumberland and North Westmorland has been Officially opened by the North-Western Electricity Board. The ceremony was performed by Mr. T. W. Jackson, vice-chairman of Penrith Urban Council. Sir Joseph Hallsworth, chairman of the North-Western Electricity Board, said the substation had been built to meet increasing demands. The Board were doing all they could to cope with the demand, but were still subject to restrictions on capital expenditure. The substation is fed from the 132-kV national grid.

River Widening Nearly Complete.—During the next few months, the River Wear Commissioners will complete a 112,000*l.* scheme for the widening of the River Wear opposite Lambton staiths, to allow larger ships to navigate the channel more easily.

Turbine Research Station.—The Wallsend research station of the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada) is to be open for inspection by representatives of the shipbuilding and engineering industry for one week commencing October 5. Admittance is by invitat on.

Coal Mines to be Closed.—Louisa Colliery, Stanley, Co. Durham, is to be closed during the next two years and the remaining coal will be worked from the adjoining Morrison Busty pit. Louisa Colliery employs 1,100 men and boys, producing about 4,800 tons of coal a week. This production will be reduced next year to about 3,500 tons, drawn on one shift a day instead of two as at present. A roadway has been driven from the Louisa pit to Morrison Busty pit. It is believed that the remaining coal deposits at the Louisa pit could not have been worked economically if the pit continued as a separate unit. Miners displaced by the development will be given work at collieries in County Durham and the West Midlands. The Hedley pit, also adjoining the Louisa pit, is to be closed about 1959, when it is expected that coal deposits will be exhausted. The pit produces 1,200 tons of coal weekly, and this will be reduced by half early next year.

Ship Building and Repairing Costs.—When the 9,600-ton cargo motorship St. John, built for the South American Saint Line, was launched at Sunderland by Joseph L. Thompson & Sons, Ltd., Mr. R. G. M. Street, representing the owners, said that it was no use pressing the Government for additional depreciation allowances for ships. What was needed was a reduction in the cost of building ships, so that ships could be operated on an economic basis. He said that shipbuilders and ship repairers should end the practice of charging increases in costs of labour and materials directly to shipowners during the period of a contract. He gave a warning that high costs would interfere with the placing of new orders and a reduction in costs was the first step towards a maintenance of building in British yards. The St. John is the ninth ship built by Messrs. Thompson for the Saint Line and its associated concerns.

Call for Improved Train Services.—Methods of improving train services on Tees-side, recommended by the Tees-side and South-West Durham Chamber of Commerce, include the introduction of Diesel-electric traction and direct trains from Tees-side on long-distance services. The Chamber consider that electrification of local railway services would be uneconomical, and though it was also agreed that the initial costs of Diesel-electric traction would be heavy, this method offered the only hope of reducing running costs and accelerating services to make them more attractive. It was also suggested that Diesel-electric locomotives could be used on the Newcastle-Middlesbrough line. On the question of fares, the Chamber said people had to be encouraged to use the railway outside peak hours, to prevent a further reduction in services. The simple fact was that people would not go out of their way to go to a railway station unless they could save time and money. The report has been sent to the local operating uperintendent of British Railways.

LANCASHIRE AND SOUTH YORKSHIRE.

The Fuel Outlook.—Members of the industrial-fuel section of the Sheffield Chamber of Commerce have been advised officially that while emergency schemes must remain ready for use in case of a cold spell, it is now considered that there will be no need for load-spreading this winter. Although stocks of coal are not as high as they were a year ago, they are not as low as they have been in previous years. Generating plant is expected to increase by about 10 per cent. this year. The output of gas is still increasing and present indications are that the record output of gas established last year will be exceeded during the coming winter. Stocks of gas coke are higher than they have been for several years.

Youth Employment.—The report of the Sheffield Youth Employment Bureau states that the regrettable movement of young persons from job to job has been arrested, the inference being that the vocational guidance given has been of value. The unsatisfied demand for boys in the heavy industries and, to a lesser extent in the cutlery trade, is still causing some concern and the liaison between schools and employers is being encouraged.

A Civic Week at a Sheffield Works.—On the occasion of a civic week at the works of Newton, Chambers & Co., Ltd., Thorncliffe, the Lord Mayor of Sheffield and members of the City Council and officials were shown round several of the firm's departments. The managing director, Sir Harold West, in welcoming the visitors, mentioned that unless the firm received orders at the rate of 30,000*l.* a day some of the people employed would be thrown out of work. It was also stated, however, that the demand for excavators and other heavy equipment was so great that the constructional shops are being extended.

Works Extensions.—A two-year programme of installation of new plant and appliances is approaching completion at the Sheffield Works of Stainless Plating Ltd. This will virtually double the works capacity and increase the labour force by about 75 per cent. One of the most notable advances made by the company is the chromium plating of three-ton steel rollers for the textile and paper industries.

Springs for Yugoslav Railway Wagons.—A visit to Yugoslavia by two members of the executive of the English Steel Corporation Ltd., Sheffield, has settled a 47,000*l.* order for the supply, to the Yugoslav State Railways, of some 37,000 coil and volute springs for the reconditioning of railway wagons. The business, hitherto, has been done by German interests who made a very strong bid for the order. The Yugoslavs had to be persuaded to accept British specifications in preference to the German specifications generally in use.

THE MIDLANDS.

Installing Drains in Railway Tunnel.—No expresses or local trains will pass through Kilsby tunnel on the British Railways (London Midland Region) main line during the five weeks from September 28 to October 31. Trains will travel via Northampton and three expresses daily will run into St. Pancras instead of Euston. These arrangements are necessary while 250 staff, working in shifts, install a new drainage system in the mile-long tunnel.

Aerial Survey of Reclamation Site.—An aerial survey of 150 acres of derelict land has been carried out for the Corporation of West Bromwich, Staffordshire. The land, which adjoins the town's boundary with Wednesbury, was formerly the site of several small coal mines and was covered by small waste heaps and flooded depressions. Large areas of similar land have been reclaimed by the Corporation in the past, using normal ground-surveying methods, but the aerial survey was decided upon in this instance because of the speed at which it could be done. It is understood that the cost of the survey has been less than if it had been done on the ground.

Railway Bridge to be Renewed.—The cast-iron bridge carrying the main Wolverhampton-Shrewsbury line of British Railways, Western Region, over the market place at Shifnal, Shropshire, is to be replaced by a steel structure. The existing bridge was built in 1849 by the Horseley Iron Company, who were responsible for several cast-iron bridges in the area. Replacement is necessary partly because of deterioration due to age, and partly to accommodate the heavier locomotives now in use. The contract for the new bridge has been awarded to the Horsehay Company, Ltd., Horsehay, Shropshire.

Industrial Coal Stocks.—Mr. A. N. Dodson, Regional Director of the Ministry of Fuel and Power, announced in Birmingham on September 15 that industrial coal stocks in the Midlands are lower than they were at the same period last year. Figures for different industries are: engineering, 6·2 weeks' stock (6·5 weeks last year); iron and steel works, 2·9 weeks (3·5); other industries, 3·7 weeks (3·9). Mr. Dodson said that there is likely to be a shortage of large coal, and suggested that, where they could use it, manufacturers should take quantities of unscreened open-cast coal as a precaution.

Information Course for Iron and Steel Industry Staff.—The Midland area training committee of the British Iron and Steel Federation have organised an information course for staffs in the iron and steel industry. It will be held at the Dudley and Staffordshire Technical College on Wednesday evenings from October 7 to November 11, and from February 17 to March 24. The subjects to be covered include the physical and metallurgical properties of steel, and the uses of steel in various forms.

The Employment Position.—The employment position in the West Midlands has improved to such an extent that part-time women workers in industry, who were discharged in considerable numbers last winter, are now in demand again. Mr. J. W. Eldridge, Deputy Regional Controller of the Ministry of Labour, speaking in Birmingham on September 15, gave this information and said that unemployment in the West Midlands now represented 0·9 per cent. of the working population, as compared with 1·4 per cent. for the whole country.

SOUTH-WEST ENGLAND AND SOUTH WALES.

East Pool Mine, Camborne.—The collapse of the pithead gear at East Pool Mine, Camborne, Cornwall, which was the subject of a Note on page 402, *ante*, did not long interrupt the use of the engine, which is used to pump water from the adjoining South Crofty Mine. The gear failed on the afternoon of Tuesday, September 15, but we learn by a letter from Mr. W. Tregoning Hooper, the honorary secretary of the Cornish Engines Preservation Society, that "Harvey's engine went to work again last Sunday," i.e., on September 20. Mr. Hooper adds that "it is a really majestic sight to see it working away at full speed, with a great deal of the engine house and roof open to the sky."

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Wales and Monmouth Branch:* Saturday, October 3, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Film on "Lloyds Nowadays." *Sheffield Branch:* Monday, October 5, 7.30 p.m., Royal Victoria Station Hotel, Sheffield. Presidential Address, by Mr. M. M. Hallett. *Lincolnshire Branch:* Thursday, October 8, 7.15 p.m., Lincoln Technical College, Lincoln. "The 'C' Process," by Mr. J. Fallows. *Scottish Branch:* Saturday, October 10, 3 p.m., Royal Technical College, Glasgow. (i) Presidential Address; and (ii) "Investment Precision Casting Without an Expendable Pattern," by Mr. A. Dunlop.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Eastern Branch:* Monday, October 5, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Industrial Applications of Hydraulic Servos," by Mr. T. Brading and Mr. G. Parks. *North-Western Branch:* Thursday, October 8, 6.45 p.m., Engineers' Club, Albert-square, Manchester. Joint Meeting with the *North-Western Centre* of the INSTITUTION OF ELECTRICAL ENGINEERS. "Design and Operation of Dunston 'B' Generating Station, with Particular Reference to 50-MW Turbo-Alternators Unitized with Reheater Boilers," by Mr. A. Howell and Mr. J. B. Jackson. *Western Branch:* Thursday, October 8, 7 p.m., Royal Fort, Bristol. "The B.R.M.," by Mr. Raymond Mays. *Scottish Branch:* Thursday, October 8, 7.30 p.m., Royal Technical College, Glasgow. Joint Meeting with the INSTITUTE OF MARINE ENGINEERS. "Scale Formation in Sea-Water Distilling Plants and Its Prevention," by Mr. Harold Hillier. Also on Friday, October 9, 6.30 p.m., North British Station Hotel, Princes-street, Edinburgh. AUTOMOBILE DIVISION.—*London:* Tuesday, October 6, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Annual Meeting and Chairman's Address.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, October 5, 6 p.m., Grand Hotel, Birmingham. Annual Meeting and Conversazione. Chairman's Address, by Mr. H. J. Gibson. *Mersey and North Wales Centre:* Monday, October 5, 6.30 p.m., Liverpool Royal Institution, Colquitt-street, Liverpool. Chairman's Address, by Mr. T. Coates. *District Meeting:* Monday, October 5, 7.30 p.m., Wig and Gown Hotel, Maidstone. "Fluorescent Discharge-Tube Circuits and Operating Problems," by Mr. J. Cates. *North-Western Centre:* Tuesday, October 6, 6.30 p.m., Engineers' Club, Manchester. Chairman's Address, by Mr. H. West. *North Midland Centre:* Tuesday, October 6, 6.30 p.m., Offices of the Yorkshire Division of the British Electricity Authority, 1, Whitehall-road, Leeds. Chairman's Address, by Mr. G. Caton. *East Midland Centre:* Tuesday, October 6, 7 p.m., Loughborough College, Loughborough. Annual Meeting. Chairman's Address, by Mr. C. D. Wilkinson. *Southern Centre:* Wednesday, October 7, 6.30 p.m., Municipal College, Portsmouth. Chairman's Address, by Commander (L) C. V. Robinson. *Institution:* Thursday, October 8, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. President's Inaugural Address, by Mr. H. Bishop.

INSTITUTION OF PRODUCTION ENGINEERS.—*Manchester Graduate Section:* Monday, October 5, 7.15 p.m., College of Technology, Sackville-street, Manchester. "Layout and Machinery Required for the Production of Clothing," by Mr. W. Bland. *Western Graduate Section:* Monday, October 5, 7.30 p.m., Grand Hotel, Broad-street, Bristol. Brains Trust Meeting. *Nottingham Section:* Wednesday, October 7, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Making a Mark," by Mr. A. Throp. *Wolverhampton Section:* Wednesday, October 7, 7.15 p.m. Wolverhampton Technical College, Wolverhampton. "Distribution of Goods in the Export Markets of the World," by Mr. H. W. Hunt. *Coventry Graduate Section:* Wednesday, October 7, 7.30 p.m., Hare and Squirrel Hotel, Cow-lane, Coventry. "Methods and Time Measurement," by Mr. R. L. Webb. *Leicester Section:* Thursday, October 8, 7 p.m., Bell Hotel, Leicester. "The Development of Copy Turning," by Mr. L. Lloyd. *London Section:* Thursday, October 8, 7 p.m., Royal Empire Society Building, Craven-street, W.C.2. "Management in the Light Engineering Industry," by Mr. R. Appleby.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Leeds Branch:* Monday, October 5, 7.30 p.m., Great Northern Hotel, Leeds. "M.I. Cables," by Mr. W. Cameron. *Sheffield Branch:* Monday, October 5, 7.30 p.m., Royal Victoria Station Hotel, Sheffield. Film Evening arranged by Messrs. Shell-Mex and B.P., Ltd. *North-East London Branch:* Monday, October 5, 8 p.m., the Angel Hotel, Ilford. Film Evening. *West London Branch:* Tuesday, October 6, 7.30 p.m., Windsor Castle Hotel, King-street, Hammersmith, W.5. "The Development of the Gas Turbine for Jet Engines," by Mr. A. C. Parkes. *Preston Branch:* Wednesday, October 7, 7.30 p.m., Preston Chamber of Commerce, 49A, Fishergate, Preston. "Power Transmission by V Belts," by Mr. A. F. McAlpin. *North London Branch:* Wednesday, October 7, 7.45 p.m., Queen's Head Hotel, Green-lanes, Harringay, N.4. "Fibreglass for Electrical Insulation," by Mr. A. M. Robertson.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Scottish Centre:* Monday, October 5, 7.30 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "The Use and Abuse of Fuels," by Mr. W. E. P. Johnson. *Eastern Centre:* Tuesday, October 6, 7 p.m., Lion Hotel, Cambridge. "Electrical Equipment as Applied to Heavy Commercial Vehicles," by Mr. W. A. Bevis. *North-West Centre:* Tuesday, October 6, 7.30 p.m., Victoria Station Hotel, Preston. "Hydraulic Transmission," by Mr. J. Houghton. *Institute:* Wednesday, October 7, 6.30 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Annual Meeting. "Transport in South Africa," by Mr. T. F. Turton (with film). *South Wales Group:* Friday, October 9, 7 p.m., B.O.C. Works, Birchgroveon, Caerphilly-road, Cardiff. Discussion on "Welding Methods" (with demonstrations). *Midlands Centre:* Tuesday, October 13, 7.30 p.m., Crown Inn, Broad-street, Birmingham, 1. "Ball and Roller Bearings for Road Transport," by Mr. M. J. Knaggs.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, October 6, 5.30 p.m., Apartments of the Geological Society, Burlington House, Piccadilly, W.1. Five papers on "Liquid-Liquid Extraction," by Mr. H. R. C. Pratt, Mr. R. Gayler, Mr. N. W. Roberts, Mr. J. D. Thornton, and Mr. R. Murdock. *North-Western Branch:* Saturday, October 10, 3 p.m., College of Technology, Sackville-street, Manchester. Joint Meeting with the CHEMICAL ENGINEERING GROUP and the *Manchester Section* of the SOCIETY OF CHEMICAL INDUSTRY. The George E. Davis Memorial Lecture, by Mr. Norman Swindin.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 6, 6.35 p.m., 39, Elmbank-crescent, Glasgow, C.2. Presidential Address, by Sir William Wallace. (Preceded by an extraordinary general meeting at 6.30 p.m.)

INCORPORATED PLANT ENGINEERS.—*Edinburgh Branch:* Tuesday, October 6, 7 p.m., 25, Charlotte-square, Edinburgh. Various short papers. *London Branch:* Tuesday, October 6, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Patterns, Casings and Foundry Work," by Mr. Barnet Levy. *Southampton Branch:* Wednesday, October 7, 7.30 p.m., Polygon Hotel, Southampton. "Oxygen in Industry," by Mr. E. Ryalls (with film). *North-East Branch:* Thursday, October 8, 7 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "The Use of Paint in Factories," by Mr. P. J. Gay. *Dundee Branch:* Monday, October 12, 7.30 p.m., Mathers Hotel, Dundee. Discussion on "Factory Instrumentation."

INSTITUTE OF FUEL.—Wednesday, October 7, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. The 1953 Melchett Lecture on "The Domestic Appliance Industry and Fuel Usage," by Dr. Harold Hartley.

REINFORCED CONCRETE ASSOCIATION.—Wednesday, October 7, 6 p.m., Institution of Structural Engineers, 11, Upper Belgrave-street, S.W.1. "Aggregate Grading and Concrete Mix Design," by Mr. D. A. Stewart.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch:* Wednesday, October 7, 6.30 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Chairman's Address on "History of Reinforced Concrete," by Mr. T. Bryce. *Lancashire and Cheshire Branch:* Wednesday, October 7, 7.15 p.m., College of Technology, Manchester. Joint Meeting with the *Manchester Branch* of the INSTITUTE OF WELDING. "Drawing Office Procedure for Welded Designs," by Mr. S. M. Reisser. *Yorkshire Branch:* Wednesday, October 14, 6.30 p.m., Great Northern Hotel, Leeds. Chairman's Address, by Mr. John Dossor.

INSTITUTE OF WELDING.—*Slough Section:* Wednesday, October 7, 7.30 p.m., The Community Centre, Farnham-road, Slough, Buckinghamshire. "Organisation for Production of Welded Ships," by Mr. D. M. Kerr. *South London Branch:* Thursday, October 8, 6.30 p.m., 2, Savoy-hill, W.C.2. Discussion on "The Aim of Weld Preparations," opened by Mr. E. Fuchs, Mr. F. C. Cocks and Mr. D. M. Kerr. *North London Branch:* Thursday, October 8, 7.30 p.m., Manson House, Portland-place, W.1. "Automatic Welding," by Mr. R. L. Swan.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*Scottish Section:* Thursday, October 8, 7 p.m., Elmbank-crescent, Glasgow, C.2. "The Microwave Test Bench and Its Components: A Practical Introduction to Wave-Guide Work," by Mr. J. Bilbrough.

TELEVISION SOCIETY.—Friday, October 9, 7 p.m., Cinematograph Exhibitors' Association, 164, Shaftesbury-avenue, W.C.2. "Recording Television Programmes," by Mr. C. B. B. Wood.

PERSONAL.

SIR FREDERICK TYMMS, K.C.I.E., M.C., is due to retire from his position as United Kingdom representative on the Council of the International Civil Aviation Organisation in January, 1954, and will be succeeded by MR. J. E. KEEL, who is at present Under-Secretary (safety and general) to the Ministry of Civil Aviation. MR. E. A. ARMSTRONG, C.B., C.B.E., now principal establishment officer, Ministry of Civil Aviation, will succeed Mr. Keel as Under-Secretary (safety and general) in the combined Ministry of Transport and Civil Aviation.

SIR REGINALD WILSON, comptroller of the British Transport Commission, and MR. J. C. L. TRAIN, C.B.E., M.C., M.I.C.E., a member of the Railway Executive since its inception in 1947, have been appointed full-time members of the British Transport Commission by the Minister of Transport. SIR HARRY METHVEN, K.B.E., chairman of the Hotels Executive, has been appointed by the Minister to be a part-time member of the Commission.

MR. JOHN ELLIOT, chairman of the Railway Executive, which came to an end on September 30, has been appointed to be chairman of the London Transport Commission, as from October 1, in succession to LORD LATHAM, who relinquished the office on September 30.

MR. HENRY NIMMO, C.B.E., M.I.C.E., M.I.E.E., M.I.Mech.E., chairman of the Southern Electricity Board and a part-time member of the British Electricity Authority, has accepted the unanimous invitation of the Council of the Engineers' Guild, 78, Buckingham-gate, London, S.W.1, to continue in office as President for the year which commenced on October 1. MR. WILLIAM LINN, M.I.C.E., M.I.W.E., senior partner of Cowan and Linn, consulting civil engineers, Glasgow, took office as chairman of the General Council on October 1.

MR. H. W. SWANN, O.B.E., M.I.E.E., retired from the positions of senior electrical inspector of factories and electrical adviser to the Home Office on September 30. He has been succeeded by MR. F. H. MANN, M.I.E.E., who has been deputy senior electrical inspector for many years.

MR. PHILIP C. N. PICKWORTH, chief engineer to B. and S. Massey Ltd., Openshaw, Manchester, 11, has been appointed a director of the company.

MR. H. S. HVISTENDAHL, B.Sc.(Eng.), M.I.Mech.E., M.I.E.E., A.M.I.C.E., has resigned his position as chief engineer of the Turbine Division of the Brush Electrical Engineering Co., Ltd., Loughborough, and has joined the staff of Merz and McLellan, Carliol House, Newcastle-upon-Tyne, as head of their investigation and tests department.

MR. W. TWADDLE has taken up an appointment on the technical staff of the Coleman-Wallwork Co., Ltd., Brook-street, Stotfold, near Arlesey, Bedfordshire.

MR. CECIL F. HURST, a director since 1938, has been appointed deputy chairman of Samuel Osborn & Co., Ltd., Clyde Steelworks, Wicker, Sheffield, 3. He has been in the service of the firm for 30 years.

MR. W. HARPER HILL has been appointed a director of the C. and M. Engineering Co., Ltd., Thames-road, Barking, Essex.

MR. ARTHUR UPTON, Associate I.E.E., has returned from the United States and yesterday resumed his position as manager of the switchgear department of Johnson & Phillips, Ltd., Victoria Works, Charlton, London, S.E.7.

MR. E. P. BRIDSON has been appointed by Finney Presses Ltd. as their representative for London and the home counties with an office at 5, New Bridge-street, London, E.C.4. (Telephone: CITy 4815.)

MR. C. BERESFORD CLARK, previously manager, marine sales, has been appointed sales manager, lubricants, to the Regent Oil Co., Ltd., 117, Park-street, London, W.1. In addition to marine business, Mr. Clark in his new appointment will be in charge of United Kingdom sales of internal-combustion engine and industrial oil.

MR. I. CLUNAS has been made manager of the Bristol office of C. A. Parsons & Co., Ltd., Heaton Works, Newcastle-upon-Tyne, 6, in succession to MR. J. PACKARD who is now manager of the firm's London office.

MR. D. S. THOMSON, who was vice-president in Winnipeg for the prairie region of the Canadian Pacific Railway, has been appointed to the newly-created position of vice-president, operation and maintenance, with the company.

F. J. EDWARDS LTD., 359-361, Euston-road, London, N.W.1, have been appointed sole agents in the United Kingdom for the distribution of machines produced by TRUMPF UND CO., Stuttgart-Weil-im-Dorf, Germany.

The Glasgow branch of W. T. HENLEY'S TELEGRAPH WORKS CO., LTD., has been transferred to larger premises at 149/153, North-street, Glasgow, C.3. (Telephone: CENtral 1771.)

SURREY DOCKS SUBSTATION OF LONDON TRANSPORT.

(*For Description, see Page* 437).

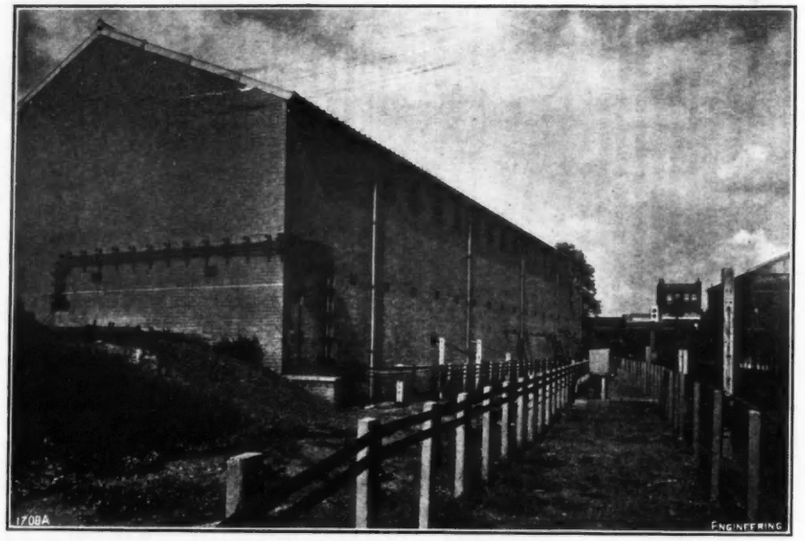


FIG. 1. EXTERIOR OF SUBSTATION.

FIG. 2. SUBSTATION INTERIOR.

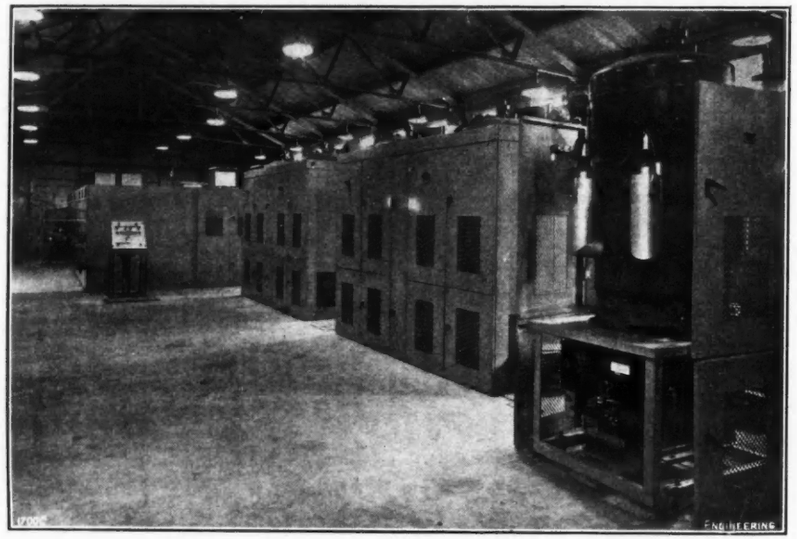


FIG. 3. 1,000-KW RECTIFIER EQUIPMENTS.

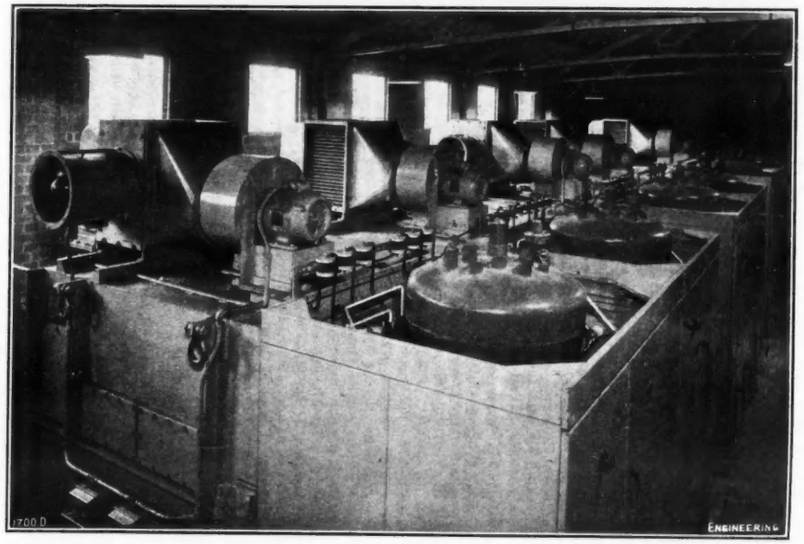


FIG. 4. TRANSFORMER-COOLING UNITS.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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ENGINEERING may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s*. 3*d*. post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s*. for the first four lines or under, and 2*s*. 6*d*. per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s*. per inch. If use is made of a box number the extra charge is 1*s*. per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, OCTOBER 2, 1953.

VOL. 176. No. 4575.

FOOTPLATE PHILOSOPHY.

THE traditional partnership of a craftsman and his apprentice is fast dying out in industry, but on the footplate of a steam locomotive the unique sense of co-operation between the driver and fireman is still much as it was a century ago. So, at least, it seems to a privileged spectator travelling on a main-line express locomotive. A "top-link" crew, especially, impress the imagination. Apart from the engineering, historical, and even romantic associations of the locomotive, there is a special quality arising from the simple fact that it requires two to man an engine. The influence of one on the other, and of the engine on them both, is something not to be found on any other machine.

If, among the creations of Nature, "the most exalted seat in the world is the saddle of a swift horse," among the creations of engineering the footplate of a steam locomotive must surely rank high. That feeling of isolation and independence which characterises the rider of a horse, the captain of a ship, or the pilot of an aeroplane, is also shared by the driver with his hand on the regulator. Perhaps that is why drivers, as they advance in years, seem also to advance in a practical philosophy of their life and work. Their fellow railwaymen in the workshops—indeed, most engineering shop workers—are denied that adventurous experience which no driver can forget, least of all when, at last, he retires and looks back on a life of railway service.

Not all craftsmen are born teachers, as any engineer who has served an apprenticeship will recall, though in most workshops there are a few admirable characters whose good influence on apprentices stems as much from their personalities as from their skill. On the footplate the relationship is closer than in the shops. During most of their working hours the driver and fireman are cut off from their fellows, and the dependence of each on the other offers greater opportunities for teaching and learning, though the fireman is not, in the ordinary sense, an apprentice. Whether or not the most is made of these opportunities, probably only a locomotive inspector could say with any certainty. The driver can do his job efficiently only if the fireman is conscientious, but equally the younger man must be aware of the idiosyncrasies of the elder before he can attend to his duties adequately.

Locomotive driving requires a certain steadiness of nerve and temperament, especially at high speeds. The violence of motion, so alarming to the inexperienced, is no doubt accepted by enginemen as normal and familiar, though different drivers react differently. They differ also in their manner of driving on up-grades and down-grades: where one will "rush" a gradient and then take the engine steadily down hill, another will not press too much uphill but will reach a high speed running down the other side.

The admirable philosophy which drivers seem to acquire in their daily work is akin more to age-old pursuits such as farming than to the superficial interests of modern industry. Many factors contribute to this. Not for them the regular shift or the monotony of "eight to half-past five." Not for them the sight of the same faces in the same bus at the same time every morning; nor the mad scramble from the clock to the works gate at "knocking-off" time. At any hour of the day or night the engineman sets forth from his home for the running shed. In summer and winter, in sunshine and rain, in darkness and daylight he goes steadfastly to work, and while other men toil like ants he enjoys the aristocratic independence of his calling. A passenger on a train can have only a slight conception of the incidents, major and minor, which daily affect the work of enginemen. On a recent run on the footplate from Crewe to Carlisle, for example, we were impressed by the too-numerous occasions, due to speed restrictions and signal checks, when the driver had to slow down the train to 15 miles an hour or less. Some of these were unavoidable, as when possible subsidence of the ground above mine workings imposed a speed restriction, but others were accidental. On the way up Shap incline, the fireman suddenly reached for the whistle handle and gave it a sharp tug. He called the driver to his side of the cab to see a sheep that had strayed on to the track. Fortunately, the whistle had made it turn back, from the down line on which we were running, to the adjacent up line, but the driver shut the regulator and brought the train almost to a stand so that he could warn the signalman at the next box. Alas! the warning was of doubtful value: almost immediately an up local passenger train passed us at speed, with the home and distant signals clear.

Earlier, we had experienced another minor incident, which might have seriously delayed the train. The fireman went to open the firehole doors, but was unable to do so as one of them had jammed. The struggle to open them, in which the three of us joined, took seven or eight minutes. Since we were approaching Shap it was an inappropriate moment for such an interruption to firing, but when at last the offending door was freed, the pressure-gauge needle was still, happily, close to the red line, and the steaming of the large boiler of the 4-6-2 "City of Chester" was quite unaffected. The fireman may, or may not, have been apprehensive, but certainly the driver evinced an imperturbability which was clearly natural to him whatever the circumstances.

These two incidents, though small, are typical, in nature if not in degree, of those interruptions to the expected routine which enginemen have to contend with and which, with experience, they learn to take quietly in their stride. Nothing, short of a serious

FIG. 4. TRANSFORMER-COOLING UNITS.
FIG. 3. 1,000-KW RECTIFIER EQUIPMENTS.

accident, can dismay the good driver. Every day's work is unpredictable and, even if it goes according to plan, the English weather can be relied upon to spring some surprises. On that run to Carlisle we passed from the industrial gloom, the rain and overcast skies of south Lancashire to the unspoilt air and sunshine of the Cumberland Fells. As we raced down from Shap at over 80 miles an hour, we passed groups of sheep grazing close to the track, more law-abiding than that other but quite unconcerned with a spectacle which, a century ago, was expected to terrify, if not kill, their ancestors. At Carlisle, where we arrived on time although we were four minutes late leaving Crewe, the engine left the train and went on to the shed. The driver and fireman were then due for a rest before returning with a night train.

Away from the footplate and back on the train (with the "comforts" of the dining car), it was still not easy to answer the question "Do drivers and firemen make the most of their opportunities to teach and learn?" The mere presence of a stranger, or even a friend, is sufficient to affect the actions and especially the conversation of a crew; so it is impossible to know what is normal practice. A footplate inspector is faced with the same difficulty, though it is part of his duty to instruct and advise. In all probability the question cannot be answered adequately. The steam locomotive is a simple machine; it is reliable, cheap to build and cheap to maintain, but it requires skill of a high order to get the best out of it under all circumstances. A knowledge of mechanics, heat engines, combustion, and workshop practice would not be out of place and would raise the standard of driving and firing. In modern engineering it is considered a fault in a machine if its successful operation depends largely on the human element. But since most men will rise to a call to exercise skill, and will take a pride in the opportunity, the prestige of the steam locomotive has always been high, and drivers and firemen, in general, have responded well. When steam locomotives are banished on British Railways—Mr. Bond's survey, reported on page 439, suggests that although the British Transport Commission are hoping for large-scale electrification, steam locomotives will continue to be designed and built for many years ahead—their power to evoke a proud and affectionate skill is likely to go with them. So long as they remain the most colourful feature of the railway scene, surely there is no fireman with soul so dead that he cannot rejoice to be on the footplate and not at the bench?

THE CORROSION OF METALS.

Either directly or indirectly, probably the whole of the work of the Chemical Research Laboratory at Teddington bears on the interests of the engineering industry. The activities of the establishment are divided into six main sections some of which appear remote from engineering, but even some of the work of the Organic Group, as, for instance, that concerned with the heats of combustion of organic compounds, may be of direct importance to chemical engineers. It is, however, to the part of the latest report* which deals with the proceedings of the Corrosion of Metals Group that most engineers will first turn.

The corrosion of metals is a subject which has long engaged the interest and activity of many bodies from the main professional engineering institutions to various research associations, university workers and others. The subject is a very wide one and, from its nature, investigations have usually to be of a long-term type. An illustration of this is furnished by work being carried out at the laboratory on the corrosion of tubes in Scotch marine boilers. This research, which is being conducted on behalf of the British Shipbuilding Research Association, has already extended over a number of years; it has been referred to in these columns on a number of occasions. The purpose of the investigation is to determine the conditions which at times result in a short life for mild-steel tubes in the boilers of trawlers and small coastal craft not utilising distilled water. The wrought-iron tubes used in the past had considerably longer lives.

From time to time, reports containing accumulated data have been furnished to the Shipbuilding Research Association, but the Laboratory staff probably would not suggest that any radical cure for the trouble has been evolved. This latest report records that experiments carried out with artificial sea-water diluted with an equal volume of distilled water showed negligible pitting, both with and without the injection of oxygen into the feed, but that doubling the sodium-chloride content in the sea-water increased the pitting, and trebling it resulted in pitting similar to that produced by undiluted sea-water. Four tests were carried out with oxygen injection and 100 per cent. sea-water, but in all cases extensive pitting resulted. Increasing the sea-salt concentration to three times that of normal sea-water did not increase the depth of pitting relative to 100 per cent. sea-water, but the extent was somewhat increased. Addition of lime and soda decreased both the depth and extent of pitting but was only partly successful in building up a protective scale. Another investigation, relating to boilers of a different type, is directed to the development of a ferritic steel for superheater tubes operating at temperatures above the present normal maximum. It is pointed out that improved boiler efficiency can at present only be achieved by the use of costly austenitic steels and heat-resisting alloys. No results are quoted in connection with this work.

An aspect of the corrosion problem of wide interest and importance relates to the attack on buried metals by sulphate-reducing bacteria. Some work has been done with non-ferrous metals and has shown that corrosion is stimulated by the proliferation of sulphate-reducing bacteria; brass, silicon bronze, manganese bronze, magnesium, aluminium, zinc and copper were affected, the attack decreasing in intensity in that order; no effect was observed with molybdenum, chromium, cobalt, cadmium and vanadium. This information will no doubt be of value in special cases but the main problem is presented by the corrosion of iron and steel. The interesting case of the perfect preservation of iron implements which had been buried for 2,000 years and were brought to light by the Inspectorate of Ancient Monuments of the Ministry of Works, has been reported in the past, and some details will be found recorded in Engineering, vol. 174, page 827 (1952). The present report states that further examination of the soil in which the objects were buried has shown that sulphate-reducing bacteria are present but inactive, although the soil contained sulphate, the conditions were anaerobic and the *p*H range suitable for bacterial activity. It was thought from the first that the freedom from attack was due to the presence of tannate in the soil but no precise measurements had been made. It has now been shown that tannic acid in concentration greater than 0·01 per cent. will suppress bacterial growth. It is suggested that this discovery may lead to improved methods of protecting buried structures and pipe-lines. It may not, however, prove easy to work out a practical arrangement applicable on an extensive scale.

Some information is given about work concerned with other methods of protecting buried pipes. Experimental lengths of 4-in. diameter spun cast-iron water mains on the L.C.C. housing estate at Chigwell have been examined after six years of burial. Pipes with a hot-dip coal-tar coating showed severe graphitisation resulting from the activity of sulphate-reducing bacteria, whereas pipes with a $\frac{3}{8}$-in. bitumen sheathing were intact. A 3-in. surround of Portland cement appeared to be providing protection, but a similar surround of aluminous cement concrete had allowed some corrosion to proceed, probably because the aggregate was too large, allowing ingress and egress of water. A 9-in. surround of gravel did not appear to be providing adequate protection; it appeared to be acting as a drain for the surrounding soil. Tests of the same type as those conducted at Chigwell are being made at Willesden, Devizes and near Fleetwood.

Probably more work has been done on atmospheric corrosion than on any other type. The atmosphere is a very variable article and the extent and aspect of exposed metal may be very different in different circumstances. The chief interest of the present report in its bearing on the matter lies in the information given about corrosion inhibitors. An apparatus has been devised for testing temporary protectives. Tests with sulphur dioxide as a solution in water gave an order of breakdown of protectives on steel which correlated well with the results obtained under sheltered outdoor conditions, but there was some divergence in the results obtained for total corrosion; this was attributed to change with age of the sulphur-dioxide concentration in the stock solution. An alternative, the use of sodium thiosulphate has been investigated; this has shown good agreement between tests conducted in different laboratories. A number of experiments have been carried out in collaboration with the British Standards Institution Committee on Standards for Anodic Oxidation Finishes. The introduction of acetic acid with or without sulphur dioxide and hydrochloric acid resulted in the pitting attack characteristic of outdoor exposure. Reference is made to the protective value of wrappings containing sodium benzoate, which are used for razor blades, needles, steel strip and rod, and other materials. A new investigation is concerned with the part played by small amounts of salts and particles left on metal surfaces subjected to different treatments in metal-finishing processes. An example of the unfavourable effect is furnished by the blistering of paint on sheet steel articles; this has been ascribed to salt contamination from treatments prior to painting.

* Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory for the year 1952. H.M. Stationery Office. [Price 4*s.* 6*d.* net.]

NOTES.

THE RAILWAYS REORGANISED.

The British Transport Commission have announced details of the interim organisation which came into force on the first day of this month. In accordance with the Transport Act, 1953, the Commission are required to prepare a scheme of railway reorganisation within 12 months, or longer if the Minister of Transport agrees. Meanwhile, the Railway Executive had to be abolished at the end of September. The Commission's primary function is now to control major policy (including finance) and general direction, "and for this purpose and to ensure a common line of action in matters of nation-wide significance as well as for the quick settlement of inter-regional questions, and for the conduct of certain common and central services, the Commission will be assisted by an expert headquarters staff." This staff, according to a subsequent announcement, includes the following new appointments: Mr. W. P. Allen (formerly a member of the Railway Executive) to be chief of establishment and staff; Mr. D. Blee (member, Railway Executive), chief of commercial services;

Sir Daril G. Watson (member, Railway Executive), chief of general services; Mr. S. E. Parkhouse (chief officer, operating), chief of operating services; Mr. R. C. Bond (chief officer, locomotive construction and maintenance), chief officer, mechanical engineering; Mr. J. Ratter (chief officer, engineering works), chief officer, civil engineering; Mr. J. H. Fraser (chief officer, engineering, signal and telecommunications), chief officer, signal and telecommunications; and Mr. A. J. Pearson (chief officer, administration), chief officer, special duties. The Regions of British Railways are remaining for the time being as now constituted, but the chief regional officers have been given certain additional powers and are known as chief regional managers. Each is to be responsible for all railway activities (commercial, operating and technical) in his region and reports directly to the Commission. London Transport continues unaltered as an Executive, under the chairmanship of Mr. John Elliot, for at least one year. The Docks and Inland Waterways Executive have been replaced by a Board of Management consisting of Sir Reginald Hill (chairman, and former chairman of the Executive), Sir Robert Letch and Mr. J. Donovan.

BRITISH OVERSEAS AIRWAYS CORPORATION.

The introduction by the British Overseas Airways Corporation of the first commercial jet air services and low-fare tourist flights on the North Atlantic route were the most important events of the Corporation's financial year which ended on March 31, 1953, the report of which has been published recently by H.M. Stationery Office, price 2*s.* 6*d.* The Comet fleet, which numbered eight at March 31, introduced the first scheduled jet services on May 2, 1952, between London and Johannesburg, and later to Colombo and Singapore. Shortly after the end of the financial year, Comet services were opened between London and Tokyo. By the end of the year the Comets had achieved a daily utilisation of six hours, and an unusually high overall load factor—i.e., the ratio of aircraft space sold to that available—of 79·4 per cent. They had earned a small profit after covering all flying and other costs, as well as interest on capital while carrying the full route-proving and training costs. Nevertheless, the cost and man-hours required for the operational development of the Comet and also of the Hermes aircraft have been high, and the Corporation are discussing with the Ministries concerned means for re-couping the costs of developing new aircraft. The high development costs contributed in some degree to the less favourable financial results obtained during the year, the main causes of which were rising costs of materials and wages, a slowing-down of world trade, the effects of the American oil strike, and the grounding of the Stratocruiser fleet for a short period in January. Thus, the profit earned by the Corporation fell from 1,233,722*l.* in the previous year to 103,875*l.*, insufficient to provide for remuneration of capital. In addition to the eight Comets, B.O.A.C.'s fleet comprised 22 Argonauts, employed on services to the Middle and Far East, and South America; 10 Stratocruisers used on first-class services to the U.S.A. and Canada, and from New York to the Caribbean; 12 Constellations, serving Australia in conjunction with Qantas Empire Airways, and on tourist services to the U.S.A. and Canada, and from New York to Jamaica and Bermuda; and nine Hermes on services to East and West Africa. The Corporation also operate six York freighters. Delivery of twelve 44-seat Series 2 Comet air-liners, with a lengthened fuselage and Rolls-Royce Avon engines, was due to begin towards the end of 1953; these aircraft will be introduced on the South American route early in 1954, and later between London and Sydney. The Bristol Britannia aircraft, the report states, holds promise of outstanding performance and operating economy; 25 are on order, the last ten of which will be the lengthened version with a much greater seating capacity. It is expected that occupation of the new engineering base at London Airport, which is under construction by the Ministry of Civil Aviation, will commence in 1954; in the autumn of that year, the Constellation and Stratocruiser maintenance base at Filton will be transferred to London Airport. The new building is 840 ft. long by 430 ft. wide, with an overall height of 100 ft. Designed on the cantilever principle, the structure provides large unobstructed floor areas. The hangar door openings are 300 ft. wide and 45 ft. high. Another development of interest referred to in the report is the possibility that the Ministry of Civil Aviation may instal an improved version of the war-time Fido fog-dispersal equipment at London Airport, which the Corporation hope may lead to a reduction in the number of diversions now inevitable in extreme fog.

KING GEORGE VI MEMORIAL FELLOWSHIPS.

To commemorate the contribution to Anglo-American understanding made by His Late Majesty King George VI, the English-Speaking Union of the United States are to award up to 25 Fellowships during the academic year 1954-55 to enable British men and women to continue their scientific and technical education in American institutions. The stipend of each Fellowship will be 2,500 dol., plus any costs of tuition and of minimum travelling. Candidates must be aged between 18 and 30 on August 31, 1954, unmarried, citizens of the United Kingdom and either holders or candidates for either a degree or Higher National Certificate by the summer of 1954. Candidates will be assigned to institutions; they may indicate their preference in this respect but the awards committee will not be bound by the preference. Further details can be obtained from Mrs. D. R. Dalton, B.A., King George VI Memorial Fund Fellowships Committee, 37, Charles-street, Berkeley-square, London, W.1, to whom completed forms and all supporting documents must be sent not later than November 14, 1953.

RAILWAY CIVIL ENGINEERING AS A CAREER.

British Railways, in conjunction with London Transport, have produced a small illustrated book, *Railway Civil Engineering as a Career*, for the guidance of young men who are still at university or at school and contemplating engineering as their vocation. The range of work involved on the railways, and their organisation in civil engineering matters, is briefly explained in the first part of the book. In the second part, the diverse character of the work is illustrated by 64 photographs showing track-work, stations and other buildings, tunnels, bridges and embankments, harbour works and laboratories, all of which are the responsibility of the civil engineer. This responsibility extends throughout the design and construction stages, continues with their maintenance during their working life, until they are finally demolished—still under the direction of the engineer—to make way for new works. It is an unfortunate fact that the railways are seriously short of qualified engineers, in spite of the great attractions of railway work so admirably detailed in the first two parts of the book. However, there is little fear that these attractions will in any way be diminished in the foreseeable future, even in the event of continued development of internal air transport, the further extension of road transport and the possible revival of the canals and inland waterways. The appropriate method of entry for graduates into the civil-engineering departments of the railways, including addresses for application, salary scales, training arrangements and conditions, are set down in detail in the third part of the book. Copies are being distributed to universities, technical colleges and the appropriate schools.

ROYAL AIR FORCE TECHNICAL CADETS.

In October, 1952, a new scheme for training technical cadets for the Royal Air Force, mainly recruited from young men leaving school at the age of 17 to 19½, was initiated at the Royal Air Force Technical College, Henlow, Buckinghamshire. On Friday, September 25, at the end of their first year, a graduation parade was held at the College; at this stage, 20 of the 31 cadets will now go to the universities for a three-year honours degree course in science or engineering; 15 to Cambridge, two to Bristol, and one each to Oxford, London and Southampton—at the conclusion of which they will return for six months to Henlow. The other 11 cadets will complete a further two years' training at Henlow, already one of the best-equipped technological colleges in the United Kingdom, and still under development. At the ceremony, the cadets were addressed by Air Chief Marshal Sir John Whitworth Jones, K.C.B., C.B.E., the Air Member for Supply and Organisation, who said that the Royal Air Force required high-grade technicians, production and maintenance engineers in numbers which would be beyond the capacities of the universities to handle. The Technical College at Henlow aimed to produce this type of officer, giving him the same status as that of the university graduate. The service also required the university-educated professional engineer, and for this reason suitable young men from the cadets had been selected for university training. Those cadets staying at Henlow would receive permanent commissions at the end of their remaining two-year course; the university technical cadets would receive their permanent commissions on graduating from the university, back-dated to the beginning of their third year at the university, so that they would not be at a disadvantage compared with those who had received all their training at Henlow. The members of these two streams, the Air Chief Marshal said, were required to possess qualities of leadership and command as well as professional and technical qualifications; for that reason, training at the College aimed at broadening and deepening the cadet's character and spirit, and providing opportunities for leadership and service. Although Henlow has been associated for many years with the training of engineer-officers, it was not until 1949 that the Royal Air Force Technical College was formed. The College consists of engineering and armament divisions, and provides 33 different courses, including some for officers of allied and friendly nations. There are at present 187 students under instruction; during the previous 12 months, 320 students have passed through the college. Studies are divided into the Basic Studies Wing; the Engineering Wing (aerodynamics, thermodynamics, structures, theory of machines, materials, applied chemistry, engines, motor transport, and marine craft); the Workshops (extensive machine shops, forge, foundry, welding shops, etc., and practical instruction on aeronautical equipment); the Electrical Wing (applied electricity, electrical machines, applied electronics); and the Armament Wing (guided weapons, servo mechanisms, and applied chemistry). The Signals Division of the Royal Air Force Technical College is still stationed at Debden.

THE LATE MR. A. B. E. BLACKBURN, C.B.E.—The death has occurred at Morpeth, Northumberland, at the age of 77 of Mr. Alfred Brown Ernest Blackburn, C.B.E., B.Sc., M.I.C.E., Hon.M.I.W.E., former engineer and general manager of the Sunderland and South Shields Water Company. He was an official of the company for about 50 years before his retirement four years ago. He was a past-president of the Institution of Water Engineers and the British Waterworks Association.

INSPECTION ROOM AT BROOK MOTORS, LTD.—For many years all motors leaving the Huddersfield factory of Brook Motors Ltd. have been given the usual tests at the end of the assembly line and a final physical inspection of external detail was given after painting. In addition to all the usual component and assembly tests a specially sound-proofed inspection room has now been constructed through which all motors must pass after completion and painting. There are two entry and exit ports forming sound traps at each end of the building, which is placed in the normal flow conveyor system from painting to dispatch. Inside this room four inspectors work in pairs opposite each other on two inspection benches placed at conveyor height. On a surface plate, checks are made for shaft concentricity and centre line height. The motor is then connected up to the correct voltage and run. A tachometer test is taken for speed; voltage and speed are checked with the motor nameplate and order details. The inspector then listens carefully to check for noises and vibration. Internal mechanical faults can be instantly detected and if the running sound is higher than is normal, owing to electrical causes, the motor is rejected.

LETTER TO THE EDITOR.

THE SHEPCOTE-LANE PLANT OF FIRTH-VICKERS STAINLESS STEELS, LTD.

To the Editor of Engineering.

Sir,—We are interested in the reference to our shears in your description of the above plant, on page 365, *ante*, but would draw your attention to the fact that the illustration used, Fig. 24, is not the shears referred to in your letterpress for dealing with sizes smaller than can be conveniently cut on the mechanised unit. It is part of the mechanised shearing line which we supplied for finish shearing and squaring sheets. The view is from the loading end and shows the first 12-ft. shears and part of the conveyor and roller tracks up to the second 12-ft. shears which is shown in the distance. The machine for cutting up small pieces is shown in the accompanying photograph and you will see that the equipment is in conformity with your description.

Yours faithfully,
For Brookes (Oldbury), Limited.
F. C. Sharp,
Director.

Oldbury, Birmingham.
September 22, 1953.

[We regret the error, and are obliged for the correction. The photograph referred to is reproduced herewith. We take this opportunity also to correct a statement in the middle column of page 363, *ante*: the 1,500-h.p. motor driving the four-high cold-rolling mill was supplied by the Metropolitan-Vickers Electrical Company, Limited, and not by the English Electric Company, Limited.—Ed., E.]

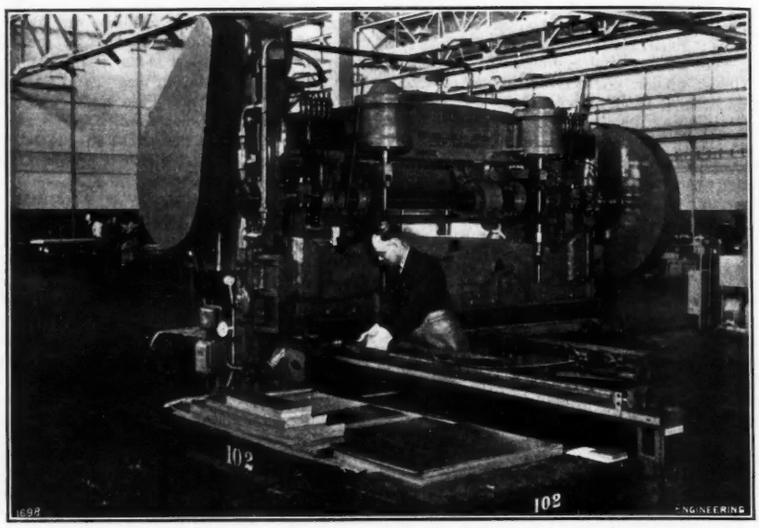
OBITUARY.

MR. PERCY BUTLER.

The news of the death of Mr. Percy Butler, which took place at his home in Edinburgh on September 21, will be received with regret by electrical engineers in this country and overseas. Mr. Butler, who was a director and joint general manager of Bruce Peebles and Company, Limited, Edinburgh, 5, was born at Normanton, Yorkshire, on January 10, 1896, and obtained his general education at Normanton Grammar School. From August, 1912, to August, 1913, he received practical training with J. Rhodes and Sons, Wakefield. In September, 1913, he entered the University of Leeds but in the following summer joined the York and Lancaster Regiment on the outbreak of the war of 1914-18. He re-entered the University of Leeds in January, 1919, and in June, 1920, obtained the B.Sc. degree in electrical engineering. He then joined the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, and became a designer of transformers. Mr. Butler remained at Trafford Park until January, 1926, when he joined the staff of Bruce Peebles and Company, Limited, Edinburgh, as senior transformer designer.

In January, 1933, he was appointed chief designer and had sole responsibility for the design of all types of transformers, rectifiers and fabricated structures involving many kinds of welded work. Promotion to the position of manager of the transformer and rectifier departments of the firm came in January, 1943. Nine years later Mr. Butler was made joint general manager of the firm and, later in the same year, 1952, was elected to the board. He became an associate member of the Institution of Electrical Engineers in 1925 and was transferred to the class of member in 1944. He served as chairman of the Scottish Centre of the Institution during the year 1951-52, and as a past chairman was a member of the Council of the Institution at the time of his death. He was also a past-president of the Edinburgh Electrical Society. Mr. Butler showed a keen interest in all electrical matters and, in addition, took a leading part in industrial Civil Defence organisations. Thus he was chairman of the Edinburgh Industrial Air-Raid Precautions Association.

SHEPCOTE-LANE WORKS.



THE CENTENARY OF ARAGO, 1786-1853.

By Engineer Captain Edgar C. Smith, O.B.E., R.N. (Ret.).

In the city of Perpignan, the capital of the department of Pyrénées-Orientales, France, stands a monument to the illustrious savant and politician, Dominique-François-Jean Arago, mathematician, astronomer and physicist and one of the outstanding men in French scientific circles when Paris was the great centre of experimental research. Like the monument to Lavoisier, in Paris, that to Arago includes a statue and bas-reliefs. The statue shows Arago speaking with his arm outstretched towards the heavens. One bas-relief depicts him as a boy, studying among the old fortifications of Perpignan, a second recalls his triumphant march in 1848 from the Paris Observatory to the Hôtel de Ville where he proclaimed the Republic, while the third shows him nearly blind and confined to bed, dictating his memoirs to his niece. There are other monuments to him at the Paris Observatory and at his birthplace, Estagel, about 10 miles from Perpignan, and there are busts of him at the Conservatoire des Arts et Métiers and in the Père Lachaise cemetery where he lies among so many other notable Frenchmen.

The son of a minor official, he was born on February 26, 1786, and attended the local schools. As a boy he owed much to a landowner who, recognising his talents and his ambition to become an artillery officer, assisted him in the study of the higher mathematics. At the age of 17 Arago realised a part of his ambition by gaining admittance to the famous École Polytechnique in Paris, having undergone searching examination at the hands of Monge and Legendre. Passing through the school with distinction, he was made secretary to the Bureau des Longitudes and so became associated with the Paris Observatory, of which he subsequently became director. His first physical researches related to optics and were carried out in collaboration with Biot. In 1806, with Biot, he was sent to the south of France to continue the measurement of an arc of the meridian begun by Delambre and Mechain but brought to a standstill through the death of the latter. After a few months Biot returned to Paris, but Arago, carrying his operations into Spain, was arrested as a spy and, during the next two years, suffered many adventures and hardships by land and sea, but, fortunately, in July, 1809, reached Marseilles bringing his charts with him. In Paris he had been given up for lost, but on his return was soon given a chair at the École Polytechnique, and though but 23 years of age, was made a member of the Academy of Sciences which he was to serve so well and so long. In the early years of the Nineteenth Century, partly owing to the enlightened views of Napoleon, there was great scientific activity, not only at the National Institutes but also at the École Normale, the Jardin des Plantes and the long established Collège de France and the Sorbonne. But owing to the wars, intercourse between British and French scientists was much restricted, and it was not until the abdication of Napoleon in April, 1814, that many of the difficulties of travel were removed. From then onwards, from the memoirs of such as Davy, Brewster, Mrs. Somerville and others it is possible to picture the world Arago lived in. Brewster, who made his first visit to the Continent in 1814 at the age of 32, described how he accompanied Biot to the National Institute, visited Laplace at his chateau, was taken to see Derthollet, talked with Humboldt and at the Institute saw Legendre "a very tall and very thin man . . . with white hair, tied and curled above the ears," Poisson, "a young and active man," Lamarck, an old man in a light coat and an embroidered waistcoat, Gay-Lussac and Delambre, both marked with the smallpox, and Prony and Cuvier. Brewster was especially attracted by Arago, then 28, "good looking, dark, very pleasant and intelligent." Thirty-six years later, when Brewster was elected one of the eight foreign associates, Arago was one of his sponsors.

Devoting his time to investigations in optics, electricity and magnetism and to popular lectures on astronomy at the Observatory, the vivacity, the enthusiasm, the eloquence and energy of Arago gradually rose in the estimation of his fellows and in 1830, after the death of Fourier, he was made perpetual secretary to the Academy of Sciences. Science, however, did not engross all his energies, for he was elected deputy for his native department and a member of the Municipal Council of Paris, his speeches on reform, education, canals and railways being listened to with the same attention as his lectures on astronomy and his *éloges* at the Academy. Though he made many notable investigations, and was awarded the Copley Medal of the Royal Society for his work in magnetism, Arago to-day is remembered largely for the influence he exerted. He supported the views of Thomas Young on the theory of light, befriended the young

SURREY DOCKS SUBSTATION, LONDON.

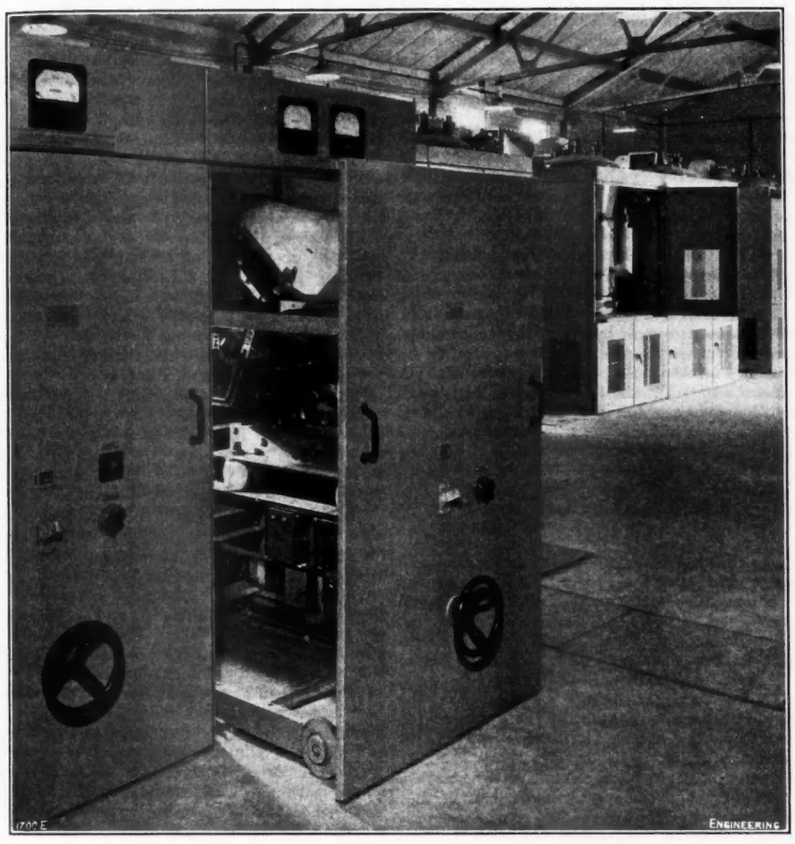


FIG. 5. DIRECT-CURRENT HIGH-SPEED CIRCUIT BREAKERS.

Italian physicist Melloni, indicated the method used by Fizeau and Foucault in the determination of the velocity of light, stimulated Leverrier's interest in the problem the solution of which led to the discovery of Neptune and wrote many biographical sketches of eminent men of science. Seventeen volumes of memoirs remain to attest to his industry and versatility.

A consistent republican he was involved in the revolution in 1830 and the downfall of Louis-Phillippe in 1848, became Minister of Marine and War to the provincial government, and as such signed the decree abolishing slavery. A sufferer from diabetes and with failing eyesight he then abandoned politics but when, after the coup d'ètat of December, 1851, Louis Napoleon came into power he refused to take the oath of allegiance. In spite of this he was left unmolested and his death took place in the Observatory on October 2, 1853. His remains were accorded a public funeral, attended by many thousands, and his funeral oration was declaimed by the chemist Barral, who edited his works. It is said that Arago's last words were "Travaillez, travaillez bien."

THE ELECTRICAL ASSOCIATION FOR WOMEN.—The 29th annual conference of the Electrical Association for Women, 35, Grosvenor-place, London, S.W.1, will be held at Torquay from Monday, May 17, to Thursday, May 20, 1954. Further particulars will be available later.

EXTENSION OF RYE HOUSE POWER STATION.—The British Electricity Authority have received the consent of the Ministry of Fuel and Power to the extension of Rye House power station, near Hertford, by two 32,000-kW turbo-generator sets and two boilers each having an evaporative capacity of 350,000 lb. of steam an hour. When completed this station will have a total installed capacity of 192,000 kW.

THE SURREY DOCKS SUBSTATION OF LONDON TRANSPORT.

THE Surrey Docks substation of London Transport, which was formally opened by Lord Latham on Tuesday, September 22, to replace one bombed during the war, is the first of a number which will be erected as part of a scheme for modernising the power distribution of the system. Considerable economy has been exercised in the construction of the building, of which Mr. T. Bilbow is the architect, with the result that it contains only 10 per cent. of the steel and 60 per cent. of the bricks and cement used in a substation of equal output before the war. These results have been achieved in spite of the fact that the substation has been built on the side of an embankment where the subsoil conditions were difficult. A view of the exterior of the substation is given in Fig. 1, page 432. As regards the electrical equipment, which was constructed by the General Electric Company, Limited, Kingsway, London, W.C.2, to the design of Mr. T. S. Pick, chief electrical engineer of London Transport, the substation is interesting owing to the employment of totally-enclosed air-cooled transformers, instead of those of the air-blast type. Oil has, in fact, been eliminated except in the high-tension circuit-breakers. As will be seen from Fig. 2, which is a general view of the interior of the substation, the equipment is mounted in rows and is visible from a central control panel. It is designed, however, so that it could be arranged as an "L," or conveniently to suit the conditions of a particular site. Another feature is that the units are portable, thus facilitating maintenance, besides enabling the foundations to be reduced to a minimum and rendering lifting tackle unnecessary.

The station is designed to convert three-phase current at 11 kV to direct current at 660 volts for traction purposes, two incoming feeders, which are connected to a double 'bus-bar metal-clad switchboard visible on the left of Fig. 2, being provided for this purpose. Four outgoing feeders are run from the same switchboard, three of which carry a supply to the rectifier equipments, while the other feeds a lighting transformer. Each of the six units forming this board is totally enclosed in sheet-steel covers and comprises an 11-kV oil circuit-breaker, with a rupturing capacity of 350 MVA, which is normally solenoid-operated though it can be worked by hand in emergency. These circuit-breakers are arranged for vertical isolation and are mounted, together with their closing mechanisms, on carriages. They can therefore be completely withdrawn for inspection and maintenance. 'Bus-bar selection is effected by lowering the circuit-breaker and moving the carriage backwards or forwards into registered positions. Ring-type current transformers, with 1-ampere secondary windings for protection and metering and 10-ampere windings for testing, are provided; and the rectifier circuit-breakers are fitted with quick-action overload trip coils, which are set to operate instantaneously at five to six times normal full load, in addition to standard increase time-limit overload and earth-leakage protection. The switchgear is equipped for frame-earth fault protection, the whole board being lightly insulated from earth, except at one point where a definite connection is made through the primary of a current transformer with a ratio of 300 : 1. Associated with the main alternating-current switchgear is a relay board. This consists of seven totally-enclosed sheet-steel cubicles, one for each of the feeder, rectifier and lighting transformer circuits and for the frame-earth fault protection. The protective and control relays and the rectifier ammeters are of the flush type and are mounted on the front of the board, while the test terminals and operating fuses are housed inside each cubicle.

The substation contains three 1,000-kW 660-volt steel-tank rectifier equipments, each of which comprises two 500-kW six-anode cylinders of the General Electric Company's pumpless air-cooled design with their associated transformers. These equipments are illustrated in Fig. 3, page 432, one of the 500-kW units being shown withdrawn in the foreground. The two cylinders normally operate together as a 12-phase unit, but can, if necessary, be run separately. Each cylinder is mounted on the top plate of a wheeled truck above its auxiliaries. After disconnecting a few leads, this truck can be completely withdrawn from its cubicle, so that all the components can be inspected.

The transformer associated with each 500-kW rectifier cylinder has a ratio of 11,000/593 (phase to neutral). As has been said, it is of the air-blast cooled, closed air-circuit type and is installed so that the end of its casing forms the rear wall of the rectifier cubicle. If the end cover of the casing is removed and certain internal leads are disconnected its core and windings, which are mounted on rollers, may be withdrawn from the case through the rectifier cubicle. One of the transformers in each 1,000-kW bush has a star-connected and the other a delta-connected primary winding, so that there is a phase displacement of 30 deg. between the outputs of the two. The secondary in each case is connected in double star through a 150-cycle interphase transformer, in order to give the necessary six-phase output. The two windings can also be connected through a 300-cycle interphase transformer for 12-phase working. Supplies for rectifier ignition and for the fan motors are taken from 242-volt tertiary windings, which also provide current for operating certain protective relays. Primary tappings, of $\pm$ 2·5 and 5 per cent., are provided, off-circuit tap changing being effected by links. Class B insulation is used throughout. The cooling equipment, which, as shown in Fig. 4, is mounted on the top of the transformer casing, consists of a Serck air to air heat exchanger. The hot air is drawn in through the exchanger tubes by an Aerofoil single-inlet fan, which is driven by a 3·5-h.p. motor, and cold air is drawn over the outsides of the tubes by an axial-type fan, which is operated by a 0·375-h.p. motor. A contactor box, which houses the protective gear and isolating switches for the fan motors, is mounted on the side of each transformer casing.

The 660-volt direct-current 'bus-bars are divided into three sections, which are interconnected through 3,000-ampere selector contactors of the line-contact type. Each section is fed from one 1,000-kW rectifier equipment, the positive connections being made through 3,000-ampere reverse-current high-speed circuit-breakers, one of which is illustrated in Fig. 5, on page 437. The negative contactors are of the line-contact type. Two track feeders are taken from each of the two outer 'bus-bar sections, the positive feeders being controlled by overload high-speed circuit-breakers and the negatives by contactors of the line-contact type. The positive circuit-breaker and the negative contactor in each circuit are electrically coupled, so that they close and open in sequence. Surge diverters are fitted to the outer-sections of each 'bus-bar. In order to avoid over-voltage under low-load conditions, a load resistor is provided for each 1,000-kW rectifier equipment and is automatically switched in by a relay and contactor when the rectifier load drops below 28 amperes, this being the combined transient load of the two transformers.

The direct-current switchgear is assembled so as to form two nine-panel truck cubicle switchboards which are installed back to back with a gangway between them. One of these boards, which can be seen in the background of Fig. 3, houses the positive high-speed circuit-breakers and 'bus-bar selector units while the other contains the equivalent negative switchgear. There is also a small test cubicle on the end of each board which contains the necessary control switches and jumpers for testing the high-speed circuit-breakers and contactors when they are withdrawn from the board. As will be seen from Fig. 5, the circuit-breakers and their auxiliary contactors are mounted on draw-out trucks, interlocks being provided so that the truck cannot be withdrawn from its cubicle until the circuit-breaker has been tripped. The load resistors are mounted above the rectifier negative contactor cubicles.

The substation auxiliary supplies are controlled from a combined alternating current and direct-current switchboard, which is fed from a 300-kVA 11,000/415/240 volt oil-immersed transformer. This board consists of four totally-enclosed sheet-steel cubicles, one containing the 500-ampere circuit-breaker which controls the supply from the transformer. Another controls the 415-volt feeders to the compressor motor and signal motor-generator sets, a third the 240-volt lighting and battery trickle-charger circuits and the fourth the circuits supplied from the 50-volt tripping battery and the 110-volt operating battery.

The Surrey Docks substation will normally be unattended and will be remotely controlled from Aldgate. Full facilities are, however, provided for local control. As regards operation, the rectifiers are started automatically by closing the oil circuit-breakers, thus energising the transformers and causing the two cylinders in each equipment to ignite simultaneously. As soon as both cylinders have ignited a sequence contactor is energised by auxiliary anode load relays and auxiliary contactors close first the high-speed circuit-breaker and then the negative contactor, thus connecting the equipment to the direct-current 'bus-bars. When only one cylinder of an equipment is operating the contact of an isolated auxiliary anode load relay, which is normally open, is cut out from the closing circuit by a link. Closing of the sequence contactor therefore depends solely on the ignition of the live cylinder. Time-delay relays are provided between the auxiliary anode relays and the sequence contactors to ensure that both the latter and the direct-current circuit-breakers will only open when sustained failures occur in auxiliary anode ignition. The track feeder and 'bus-bar selector circuit-breakers are electrically operated by 660-volt closing and tripping contactors. 'Bus-bar track selector contactors are also provided, so that the feeder circuit-breakers can be closed when the direct-current 'bus-bars are dead.

The 11-kV circuit-breakers, of course, trip automatically when their protective devices operate. Most of the relays are self-resetting, but lock-out relays are embodied in the rectifier feeder circuits, the operation of which is initiated by earth faults on the main or isolating transformers, by failure of the transformer or rectifier fan drives and by repeated failures in the starting sequence after three re-starts have been attempted. The occurrence of any of these faults is indicated by a lock-out alarm on the supervising panels at Aldgate and by a lock-out indicator in the substation itself. In each case local inspection and hand re-setting of the relays are necessary. Should the transformer fan fail the faulty motor is indicated by a flag relay at the front of the contactor box on the transformer casing. When the fans are switched off during low-load periods the associated circuit-breaker tripping circuit is automatically cut out at the same time.

The track feeder circuit-breakers trip automatically on overcurrents, which are dependent upon the settings of calibrated resistors, these settings being variable between 3,000 and 6,000 amperes by six-way stud switches. The circuit-breakers may also be tripped by operating the tunnel trip wires, thus de-energising the tunnel trip contactor and breaking the circuit to the hold-on coil. In case of emergency the high-speed circuit-breaker can be reclosed before the tunnel trip contactor is re-energised by operating a latched push button on the front of the track cubicle. All the track feeder high-speed circuit-breakers are designed to hold in at direct-current 'bus-bar voltages down to 400 volts.

THE INSTITUTE OF METALS.

As recorded on page 402, *ante*, the 45th annual autumn meeting of the Institute of Metals opened in Southport, Lancashire, on the evening of Monday, September 21, with the delivery of the 24th annual Autumn Lecture, entitled "The New Metal Titanium," by Dr. Maurice Cook. This is reprinted on page 427 of this issue. On Tuesday morning, September 22, the meeting was continued in the Town Hall, Lord-street, and at the outset of the proceedings, the chair was occupied by Lieut.-Commander G. K. Rylands, O.B.E., R.N., J.P., chairman of the reception committee, who gave a formal welcome to the visitors on behalf of that committee. His Worship the Mayor of Southport, Alderman William Tattersall, A.M.I.Mech.E., J.P., extended an official welcome to the members, delegates and their ladies to the town of Southport. He stated that the exchange of ideas between scientific men was of great advantage to all in the technical world and he wished the meeting every success.

Mr. W. B. Wragge, President of the Manchester Metallurgical Society, then welcomed the members and guests on behalf of the two "host" societies, the Manchester Metallurgical Society and the Liverpool Metallurgical Society. He stated that the Institute had held its autumn meeting three times previously in Lancashire, namely, in 1923 and 1934 in Manchester and in 1928 in Liverpool. The metallurgical industry, he continued, was fairly well represented in the County. In and around Liverpool, apart from the shipbuilding industry, a good deal of non-ferrous metallurgical work was carried on. Manchester, on the other hand, was more representative of the steelmaking industry, which was conducted at Irlam and elsewhere. There were also, however, the magnesium producing works at Clifton Junction. It was of interest to note that the joint membership of the two host societies totalled between 300 and 400—mainly of the works-metallurgist type, with a sprinkling of academic men. In returning thanks, the President of the Institute, Professor F. C. Thompson, said that some 300 members, ladies and delegates from overseas had come to attend the meeting in Southport.

After the official welcome, the meeting passed on to the reading and discussion of technical papers. Two concurrent scientific sessions were held, the first, session "A," being devoted to the discussion of papers of industrial interest, and the second, session "B," to papers on physical metallurgy.

Stretcher-Strain Markings.

The first portion of session "A," which was presided over by Dr. C. J. Smithells, M.C., was devoted to a discussion on the theme of "Stretcher-Strain Markings," based on seven papers published in the *Journal* of the Institute. The first paper was entitled "Some Observations on the Occurrence of Stretcher-Strain Markings in an Aluminium-Magnesium Alloy," and was by Mr. R. Chadwick and Mr. W. H. L. Hooper, of Imperial Chemical Industries, Limited, Metals Division, Witton, Birmingham. These authors stated that they had made detailed observations of the appearance of, and dimensional distortion associated with, surface markings developed by the progressive stretching of aluminium-3 per cent. magnesium alloy sheet in different conditions of cold working and annealing. In material of 0·025 mm. grain-size, markings developed with a very small strain and were at first normal to the tension axis but subsequently became random in direction, reaching maximum intensity at about 1 per cent., and decaying within a 2 per cent. extension. These random markings consisted of a series of kinks and there was no thinning of the sheet. Parallel bands caused by local thinning or necking, were of much less intensity than the random markings which were the main cause of defects in pressing operations. When the grain-size exceeded 0·05 mm., random markings did not occur in stretching; neither were they obtained in partly-annealed or temper-rolled sheet, irrespective of grain size. Parallel bands were found in all these materials. When the grain-size was increased substantially, the well-known "orange-peel" effect, or roughening, developed on stretching and completely masked any other effect.

The second paper, by Mr. W. H. L. Hooper, dealt with "The Influence of Composition on the Incidence of Strain Markings in Aluminium Alloys." Mr. Hooper stated that it had been established that, in aluminium-magnesium alloys of commercial and high purity, magnesium itself, rather than impurities or grain-refining additions, was responsible for stretcher-strain effects, which were absent with less than about 1 per cent. of magnesium and severe only with more than about 2 per cent. of that element. Low-intensity markings were developed in aluminium-copper-magnesium alloys after quenching to retain the alloying constituents in solid solution. It was concluded that, as in mild steel, strain markings were associated with atomic rearrangement in an unstable, supersaturated solid solution.

"The Stepped Stress-Strain Curve of Some Aluminium Alloys" was the title of the third of the seven papers. It was by Mr. N. Krupnik and Professor Hugh Ford, of Imperial College of Science and Technology, London. The authors stated that, with a view to establishing basic yield-stress curves, tensile tests had been made with poor aluminium alloys pulled at constant rates of either loading or straining. It had been found that alloys which showed stepped yielding over the whole stress-strain curve under normal testing conditions could be made to give a smooth stress-strain relation only under special test conditions, namely (*a*) very low rates of stress, and (*b*) constant rates of strain. The smooth curve, where it was obtained, appeared to agree well with the envelope of the stepped curves for the same material, the steps being deviations below the basic curve. It had been found that any sudden disturbance of the testing machine caused an otherwise smooth yield curve to breakdown into steps, and this might explain some of the irregularities observed in tensile tests on these alloys using normal testing methods.

Dr. N. H. Polakowski, of the Metallurgical Department, University College, Swansea, was the author of the fourth paper, on "Discontinuous Flow and Strain-Ageing in a 6-per cent. Tin Phosphor-Bronze." The author stated that the purpose of the present work was to investigate, in some detail, the deformation and strain-ageing behaviour of a cubic, face-centred α-bronze, and to compare it with that exhibited by ordinary mild steel in similar circumstances. Tension tests had been carried out on 0·2-in. diameter rods after various initial treatments. The yield-point discontinuity was found to increase in size with total strain, and reached about 7 per cent. in samples which were prestretched to a sufficient extent and aged afterwards. The fronts of the Lüders deformation waves were sharp in fine-grained, but very diffuse in coarse-grained material. By analogy with steel, the results obtained were felt to support the idea that "flamboyant" and parallel-band

markings were caused by fundamentally identical mechanisms.

The fifth paper was a communication from the British Non-Ferrous Metals Research Association, by Dr. V. A. Phillips, Mr. A. J. Swain and Mr. R. Eborall. It was entitled "Yield-Point Phenomena and Stretcher-Strain Markings in Aluminium-Magnesium Alloys," and the authors stated that they had correlated the formation of stretcher-strain markings in aluminium-magnesium alloys with the stress-strain diagram. There was an initial yield, similar to that of steel, and the deformation associated with this, which was a shear, produced markings resembling Lüders markings in steel. In pressing, markings of this type (type A) occurred in lightly-strained regions, and constituted a serious defect. This type-A yield was characteristic of the fine-grained, recrystallised alloy. It was absent in coarse-grained materials, and was also absent in materials which had been worked, even if subsequently aged. In a tensile test at room temperature, there were many subsequent yields. These (type-B) yields had been found to be due to strain-ageing during the test. The associated deformation had been confirmed to be a symmetrical thinning without shear, and the markings did not become conspicuous unless a heavy stretch were applied. The yields produced by strain ageing were hardly sensitive at all to changes in grain-size, and still occurred in material which did not show type-A yielding.

The sixth paper dealt with "Some Methods of Measuring Surface Topography as Applied to Stretcher-Strain Markings on Metal Sheet" and was by Mr. W. H. L. Hooper and Dr. J. Holden. The authors stated that two methods had been used, the first involving the Talysurf surface-measuring instrument and the second, light-interference effects. The Talysurf consisted essentially of a stylus tipped with a diamond of 0·0001 in. radius, which made contact with the surface under examination. The rise and fall of the stylus as it travelled over the surface were magnified electronically, and these magnified displacements were traced by a high-speed autographic recorder, the magnification chosen for stretcher-strain measurements being × 1,000 vertically and × 2 horizontally. Traces were taken from both surfaces of the specimen between two fixed points. The interferometry method involved covering the area of the specimen under examination with a small thin piece of optical glass, and illuminating the covered area by a parallel beam of monochromatic light. The specimen was viewed through a metallurgical microscope, modified by placing an extra iris diaphragm in the illumination arm; the usual 16-mm. objective was satisfactory. Interference fringes were produced, and their changes in separation and direction indicated the topography of the surface in the field of view.

The two methods were complementary. The Talysurf was particularly suitable for examining both surfaces of a sheet specimen, but the measurement of an area was a lengthy operation. By means of interferometric techniques, the contours of small areas were clearly indicated. Used in conjunction, therefore, the two methods had a scope and versatility which were adequate for most problems involving surface-profile measurements in the laboratory.

The seventh and last paper in the series on "Stretcher-Strain Markings" was another communication from the British Non-Ferrous Metals Research Association, by Dr. V. A. Phillips, and was entitled "Effect of Composition and Heat-Treatment on Yield-Point Phenomena in Aluminium Alloys." Dr. Phillips stated that he had studied discontinuous yielding in commercial aluminium and some common alloys not containing large amounts of magnesium. The initial yield found in fine-grained aluminium-magnesium alloys was weak or absent in the materials studied, even when the grain-size was fine, but strain-ageing effects were present, the strength of which depended on the composition and heat-treatment. These effects gave rise to stepped stress-strain curves at room temperature. The increase in flow stress produced by ageing after straining at a low temperature could be separated into two parts, σ_s, a transient increase which disappeared as soon as further deformation took place, and σ_p, a permanent increase which raised the level of the whole subsequent stress-strain curve.

Discussion.

The discussion on the above papers was opened by Dr. W. A. Baker, who stated that they had gone a long way towards elucidating some of the difficulties connected with the problem of stretcher-strain markings. A subsequent speaker, Dr. B. B. Hundy, drew attention to the similarity between the markings which occurred on an aluminium-magnesium alloy pressing and a mild-steel pressing. Two slides shown on the screen illustrated a striking similarity. Professor H. Ford, who also contributed to the discussion, said that in the paper by Mr. Krupnik and himself only type "B" yield had been investigated; there had been no type "A" yield, which would have complicated their observations. The next speaker, Mr. R. Chadwick, said that type "A" yield gave rise to random or "flamboyant" markings. They were the resulting complex strains. Type "B" markings consisted of a cross-hatching of closely spaced parallel bands inclined at an angle of about 57 deg. on either side of the line of stretching. These bands increased progressively in intensity, until necking and fracture eventually occurred on one of them. His own view was that the two markings, "A" and "B," could occur together, particularly when the stresses were complex.

Mr. A. J. Field stated that these stretcher-strain markings were not new; they had been observed 30 years ago after the tensile-testing of sheet specimens. The final point raised by several speakers in the discussion related to effects connected with the annealing and quenching of aluminium-magnesium alloys. It was pointed out, for instance, that when quenching an alloy of this type from 500 deg. C. this was usually conducted on material heated in a salt-bath furnace. The question was whether the mixtures of sodium and potassium nitrates, of which the salt bath was composed, would attack the alloy, and, further, whether, after quenching from 500 deg. C., the alloys were rendered more susceptible to stress corrosion. One of the speakers, Mr. Christopher Smith, stated that, in his company's works, aluminium alloys containing 7 per cent. of magnesium were regularly annealed in salt-bath furnaces without giving rise to any trouble. Other speakers considered it unlikely that a quenching treatment would render the aluminium-magnesium alloys more liable to stress-corrosion effects.

(To be continued.)

Symposium on Aspects of Technical Writing.—Five meetings of the Presentation of Technical Information Discussion Group during the coming session will be devoted to a "Symposium on Aspects of Technical Writing." The first meeting of the series will take place at University College London, on Wednesday, October 14, commencing at 6 p.m., when the President of the Group, Professor R. O. Kapp, will read a paper on "The First Draft." Other meetings will be held in November, 1953, and in January, February and April, 1954. Further particulars may be obtained from the Group's honorary secretary, Mr. B. C. Brookes, University College London, Gower-street, W.C.1.

Building Research Station Films.—From October 1, films produced by the Building Research Station on technical subjects will be distributed by the Ministry of Works. A new film, No. A.10, entitled "House-building with a Tower Crane," is now available; it runs for 23 minutes. Also available are: A1, "External Rendered Finishes: A Survey of Continental Practice" (silent, 35 minutes); A2, "The Spray Method of Cleaning Limestone Buildings" (silent, 14 minutes); A3, "How Tree Roots Can Damage Buildings" (sound, 11 minutes); A4, "Experiments in Blocklaying" (sound, 14 minutes); A5, "Foamed Slag Concrete" (sound, 33 minutes); A6, "Building on Shrinkable Clays" (sound, 8 minutes); A.7, "Aerated Concrete" (sound, 21 minutes); A.8, "Parapet Walls" (sound, colour, 9 minutes); and A.9, "Handling Concrete on Housing Sites" (sound, 31 minutes). Requests for loans—for which there is no charge—should be made, giving at least a fortnight's notice, to the Film Officer, Ministry of Works, Lambeth Bridge House, London, S.E.1; or to the Ministry of Works in Edinburgh or Cardiff, or the appropriate regional officer.

MOTIVE POWER ON BRITISH RAILWAYS.

In his presidential address to the Institution of Locomotive Engineers, delivered on Wednesday, September 23, Mr. R. C. Bond said that although the broad economics of the case had so far compelled the retention of steam traction as the principal form of motive power in this country, and new steam locomotives continued to be designed and built, the conditions necessary to establish a more rapid and extensive change to electric and Diesel traction in the fields for which each was most suitable had never been more favourable than at present. Since the war, he said, the severe limitations imposed on capital expenditure had curtailed the possible rate of progress with electrification. Large schemes were under consideration which, if authorised, would impose a heavy burden on the manufacturing capacity available to the home market. The technical staff of British Railways were engaged in the development of prototype electric locomotives and multiple-unit vehicles in preparation for the time when large numbers would be required.

Referring to internal-combustion locomotives, Mr. Bond said that they were handicapped on economic grounds, in addition to the high price of oil compared with coal. The first cost of construction was at present from three to four times as much as for steam locomotives of similar power. It would hardly seem possible for internal-combustion locomotives to show a net reduction in total costs, except on those main-line services where traffic conditions permitted their high availability to be utilised to the extent of running three or four times the mileage per annum achieved by steam locomotives. The small number of main-line Diesels at present in service were averaging 3,500 miles per week on express passenger services, but the number of engine workings which could be arranged to permit such mileages were very limited, and even more miles per annum were needed to offset the higher first costs. Diesel shunting locomotives, however, with only one man on the footplate, were firmly established as a most profitable investment, and there were encouraging possibilities of economy in the operation of many secondary services by multiple-unit Diesel rail-cars.

Surveying the improvements in steam-locomotive design which have taken place since 1923, Mr. Bond said that the general conclusion was that with locomotives representative of contemporary design on express passenger services there had been an improvement in overall efficiency in terms of coal burnt per drawbar horse-power hour of something like 30 per cent. In the larger modern locomotives boiler efficiency was often not less than 70 per cent. when fired at a rate of 3,000 lb. of coal per hour, which was about the maximum one fireman could maintain. Evaporative performance to-day was very similar to what it was 30 years ago. Indeed, the trend towards higher steam pressure and temperature actually operated to reduce the efficiency of the boiler itself on account of the necessarily higher smokebox-gas temperatures which went hand in hand with hotter steam. It was to improvement in cylinder efficiency that credit must largely be given for the substantial increase in overall efficiency which had been achieved. However, increased boiler pressures had made higher cylinder efficiencies possible by increasing the heat drop between admission and exhaust. The cylinder efficiency, relative to the Rankine cycle, of the Britannia-class 4-6-2 mixed-traffic locomotive reached nearly 70 per cent. of the maximum theoretically possible.

Mr. Bond reviewed the experience with six steam locomotives of unconventional design. One of these was the Leader class of the former Southern Railway. He said, with regard to this type, that since the high availability and reduction in maintenance costs and fuel consumption which were aimed at were just those things for which they were continually striving, the utmost pains were taken to overcome initial troubles and to give this unusual design every opportunity to prove its worth. A number of modifications were made and many trial runs were undertaken but the locomotive

could not be made capable of sustained work or reliable performance. The principal causes of trouble were breakages of valve-gear parts, fracture of the crank-axle and difficulties with the brick walls of the firebox. The engine weight was excessive and its distribution faulty. The firing cab was excessively hot and careful tests showed no improvement in thermal efficiency.

With the increase in the size and first cost of locomotives in recent years it had become more than ever important to reduce the burden of the interest charges and provision for renewals by spreading them over high individual mileages per annum. Locomotive utilisation was influenced very much by geographical and traffic conditions. It was seldom possible to employ locomotives continuously in hauling trains for so long each day as the technical characteristics would quite readily permit. The economies resulting from intensive use of locomotives had long compelled departure from the old rule of each driver having his own engine, and they were the principal reason for the large increase in the number of mixed-traffic locomotives. The increase which had taken place in the number of brake-fitted freight trains running at speeds approaching those of passenger services had been largely responsible for the trend away from the traditional 0-6-0 wheel arrangement for mixed-traffic duties. The free-running characteristic of modern locomotives had enabled engines to be built with coupled wheels small enough to allow the high tractive effort needed for freight service to be developed from cylinders of reasonable size, without any restriction of the speed capacity essential for working express passenger trains. Nearly one-third of the 19,000 locomotives of British Railways were to-day suitable for, and were used quite impartially on, a very wide range of services, and to them should go credit for a large part of the increase of 25 per cent. in the miles per day per engine in use.

An important consideration arose as to the extent to which new steam locomotives should be built concurrently with the progressive change in the kind of traction. A large-scale conversion to a different form of traction would release many steam locomotives for service elsewhere, and from the point of view of numbers alone it would no doubt be possible to work the diminishing steam services without any new steam-locomotive building. A considerable proportion of the displaced locomotives would be in the higher power groups because, apart from suburban services, the most heavily-loaded main lines would be the first to be converted. These large locomotives might not necessarily be particularly modern, and it would not be economical to draft them to secondary duties well below their power capacity. Unless, therefore, the displaced locomotives could be used economically on services suited to their capacity they should be scrapped.

At the same time, the fullest possible advantage should be taken of the economies which modern design made possible. It was not unreasonable to expect an improvement in thermal efficiency from the present average level of about 5 per cent. to 7 per cent. if, by the normal process of replacement of the older locomotives, the stock included a steadily increasing proportion of modern types. This was a relative improvement of 40 per cent., and if it could be assumed that only one-half of the potential economy could be turned to good account in daily service on a number of locomotives equal to one-third of the present stock, the reduction in coal consumption would amount to nearly a million tons per annum. The largest single source of further economy in steam traction costs was in reduction of expenditure on maintenance in shops and sheds. Although the average mileage between repairs and works had increased by nearly 30 per cent. during the last 30 years, there was considerable scope for further improvement.

"Let us finally remember," Mr. Bond said, "that any form of motive power is only a means to an end, and what may be best at a particular time or place may not always and everywhere be the right solution . . . . let us exercise our judgment upon them with strict impartiality, having only in view the objective of the most efficient and economical transport service."

LABOUR NOTES.

Wage problems were discussed at some length at a meeting in London on Friday last between representatives of the two sides of the coal-mining industry. For some time past, the National Union of Mineworkers has been anxious to obtain further advances in pay on behalf of all men engaged on a day-wage basis, and it now appears to be the union's intention to ask for an increase of 2*s.* 1*d.* a shift for those working on the surface and of 2*s.* 3*d.* a shift for those employed underground. As miners who complete five shifts in any week are paid for six, these demands are equivalent to increases of 12*s.* 6*d.* and 13*s.* 6*d.* a week, respectively. The present minimum rates are 6*l.* 7*s.* 6*d.* a week for surface employees and 7*l.* 6*s.* 6*d.* for underground operatives. According to present information, some 400,000 miners in the lower-paid grades are likely to be involved in this new wage claim.

Last Friday's talks, which were informal only, were apparently concerned mainly with the background to the claim and the discussions are understood to have ranged over such matters as production, costs, sales, and the economic position of the industry generally. No doubt the fact that a claim of the size contemplated, if granted in full, would add about twelve million pounds a year to the wage bill of the National Coal Board was given due consideration. The results of the meeting are being reported to the full executive committee of the union. The Board was represented at the meeting by their chairman, Sir H. Houldsworth, and by Mr. W. H. Sales, who has succeeded Mr. Ebby Edwards as the member of the Board principally concerned with labour relations. Sir William Lawther, the President, Mr. Ernest Jones, vice-president, and Mr. Arthur Horner, general secretary, represented the union. It is expected that the actual claim will be presented later this month and that formal negotiations will be opened on October 13.

The appointment of Mr. W. H. Sales as a full-time member of the National Coal Board, to fill the vacancy caused by the retirement of Mr. Ebby Edwards, the member of the Board previously responsible for labour relations, was announced by the Ministry of Fuel and Power on September 23. Mr. Sales, whose new post is tenable for five years, was previously deputy-chairman of the North-Western Division of the Board.

Increases in wages in the asbestos-manufacturing industry came into force last Monday, in accordance with the terms of a recent award by the industry's Joint Industrial Council. Adult men in the textile section received 2*d.* an hour more and adult women an increase of 1½*d.* an hour. Men and women employed on the non-textile side received a further 1*d.* an hour. In all, some 3,000 operatives benefited from the increases. Their union had put forward demands for an increase of 3*d.* an hour for all employees. The question of a guaranteed week has been deferred for further consideration.

Demands for an all-round increase of 9*d.* an hour in the wages of operatives in the building industry are to be presented to the employers when the industry's national agreement comes up for its annual review. The campaign for the increase is due to be launched next month. This course was decided upon at a conference in York last Friday, which was attended by some 80 delegates from the 18 unions affiliated to the National Federation of Building Trades Operatives. The new demands are being put forward because a previous claim, for an advance of 6*d.* an hour, was rejected by the Industrial Disputes Tribunal last May, and on account of further increases in the cost of living.

In a statement issued after the conference by the secretary of the men's Federation, Sir Richard Coppock, C.B.E., it was pointed out that between 20 and 30 per cent. of the Federation's members were already receiving the equivalent of the proposed increase, and it was felt the higher rate of pay should be made applicable throughout the country. Employees in the industry number about one million and according to estimates made earlier this year by the employers' organisation, the National Federation of Building Trade Employers, an all-round increase of 9*d.* an hour would represent an addition of about 90 million pounds a year to the industry's wage bill and of about 90*l.* to the average cost of council houses.

Some 1,307,000 workpeople in the United Kingdom received increases in their full-time weekly wages during August, and these were estimated to amount to a total of approximately 337,000*l.* net, representing an average of nearly 5*s.* 6*d.* a head. The *Ministry of Labour Gazette* for September records that, among the principal groups of workpeople who benefited from these increases, were persons employed in agriculture in England and Wales, the cotton industry, and the iron and steel industry. Other classes who received additions to their pay included operatives engaged in leather production, glass-container manufacture, co-operative laundries, and wood-box, packing-case and wooden-container manufacture.

Increases in the iron and steel industry were payable under sliding-scale arrangements based on variations in the interim index of retail prices. On the other hand, there was a decrease in wages during the month, amounting to 21,000*l.* net. This principally affected employees engaged in the manufacture of boots and shoes, and was also due to sliding-scale arrangements based on the retail-prices index. The anomaly was due, apparently, to the fact that the effect of the decline of the index figure by one point during August came into operation in the boot-and-shoe manufacturing industry more quickly than in the case of the iron and steel industry. The effect of the decline on the latter industry should be noticeable when the figures for September are available.

Stoppages of work in the United Kingdom, owing to industrial causes, were rather more numerous during August than in the previous month, and were slightly more serious in character. Altogether, there were 132 disputes in progress during August, and, in them, some 19,600 persons were involved and about 56,000 working days lost; while, during July, the number of disputes in progress totalled 103, and, in these, only 15,200 workpeople took part and only 32,000 days were lost. During August last year, however, there were 175 strikes. In these, 44,900 workpeople were involved and over 167,000 working days lost. During the first eight months of this year only 1,057 stoppages have arisen, compared with 1,173 during the corresponding months of 1952.

A number of disputes have occurred recently owing to difficulties about breaks in working hours for tea. A further instance arose last Friday, when over 250 maintenance men employed at the atomic-research factory of the Ministry of Supply at Salwick, near Preston, left their work to discuss this question with officials of their unions, after the management was stated to have declined to allow the men to hold a meeting during their lunch interval. The discussion is stated to have lasted for an hour and a half, during which work was interrupted.

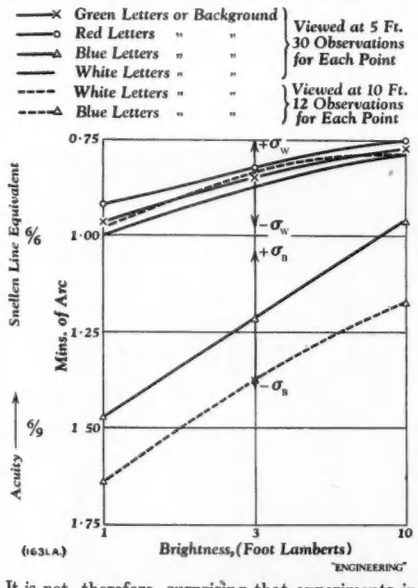
The men, who belong to the Electrical Trades Union, the Amalgamated Engineering Union, and to unions in the building industry, object to the amalgamation of two ten-minute tea breaks during the day into a single break of 20 minutes in the morning. They had staged a 24-hour token strike on the previous Wednesday and they decided, by a large majority, to return to work provided certain conditions were observed. These included provisions that there should be no overtime, that work should be performed strictly to rule, and that a ten-minute break should be taken each afternoon irrespective of whether tea was provided in the factory's canteen. Another condition was that the shop stewards and the management should resume their normal relationship.

THE APPLICATION OF COLOUR TO TELEVISION BROADCASTING.*

By F. C. McLEAN, C.B.E., B.Sc., M.I.E.E.†

EXPERIMENTS on the composition of coloured light go back at least 200 years. In his treatise on *Opticks*, Sir Isaac Newton established that white light could be simulated by a mixture of coloured lights, and that nearly all colours could be simulated by a mixture of three colours only; when we are considering an additive system of colours, the three colours concerned are red, green and blue. He also showed that it was immaterial whether the colours were added together simultaneously or sequentially, provided that in the latter case the rate of succession was sufficiently high. Further fundamental work was carried out by Young, Clerk Maxwell, and others, and the basic requirements for colour synthesis were established. Colour television awaited the development of means of achieving television itself, and was bound to follow the development of this basic system.

Fig. 1.
VARIATION OF MEAN ACUITY WITH BRIGHTNESS.
Surround Brightness Approx. Equal to Chart Brightness



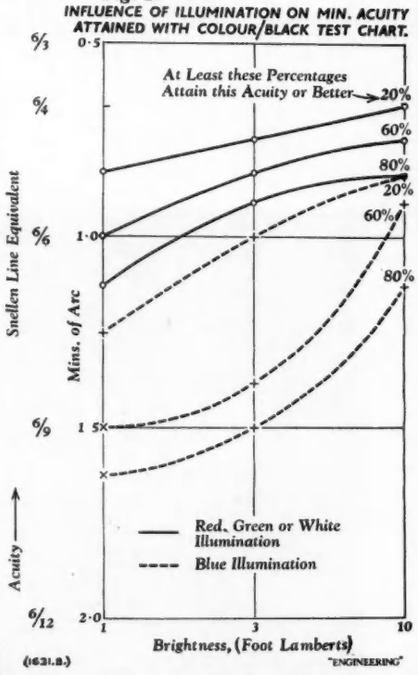
It is not, therefore, surprising that experiments in colour television started very soon after the first successful black and white television, and Baird was demonstrating a simple form of colour television in 1927. The real advance towards a successful colour television system was, however, not to begin until intensive research into this problem began during the past decade, principally in the United States. A large part of the big advances in the art has resulted from work carried out by a number of important organisations in that country, and the information on various colour television systems in this paper is to a large extent founded on information from these sources. Consideration will be given only to colour systems suitable for broadcast transmission and home reception. The somewhat simpler problem of closed-circuit transmission, where bandwidth limitation is not serious, will not be discussed.

The essential problems of colour television broadcasting concern not so much the production of a coloured picture as such, as this can be done in a number of ways, but to produce a picture that can be received in the home on equipment that will be reasonable in cost and in size, will give adequate fidelity of reproduction, be reliable in operation over prolonged periods without complex adjustments, and will do all this while being economical in the bandwidth used. Together with this consideration is the problem of the extent to which the existence of several millions of black and white receivers shall be allowed to influence the decision on the colour system to be adopted.

In all discussions on colour television systems the terms "compatible" and "non-compatible" continually occur, and can be defined as follows. A "compatible system" is one in which an existing monochrome receiver can without modification reproduce a black and white picture from the same transmission as will produce a colour picture on a suitable receiver. A system is "non-compatible" if the existing receiver cannot reproduce a black and white picture from such a transmission. Broadly speaking, this means that the brightness components of the picture, at least, must be transmitted in the same bandwidth, to the same standards, and on the same channel, as the monochrome picture.

All these requirements reflect directly on the generation of the signal and necessarily imply the addition of complication at the transmitter and camera end in order to achieve as much simplification as is possible at the receiver end. It appears true to say, however, that compatibility implies much more complication at both the transmitting and receiving ends than does non-compatibility. The complications at the transmitting end are likely to be readily accepted, and the final criterion is the receiver in the home of the viewer. This paper will outline some of the problems involved and the factors influencing a decision.

Fig. 2.
INFLUENCE OF ILLUMINATION ON MIN. ACUITY ATTAINED WITH COLOUR/BLACK TEST CHART.



Definition Requirements.—It is widely accepted in television that the signal transmitted should not be any more detailed than is necessary to give a pleasing reproduction, and this is especially so if colour information is also to be transmitted. To send more than the minimum information is prohibitively expensive in wavelength space and in money at all stages in the chain from the camera to the receiving set. In the United States the accepted standard for monochrome transmission is a picture based on a line frequency of 15,750 cycles per second and a repetition rate of 30 complete pictures per second, as compared with the British standard of 10,125 cycles per second and 25 complete pictures per second. In the American case all the information is transmitted within a channel width of six megacycles per second and a video band of four megacycles per second, and in the British case within a channel width of five megacycles per second and a video band of three megacycles per second. To transmit the full definition in all colours would necessitate three times these bandwidths. To obtain apparent equal definition in colour it is, however, possible to degrade somewhat the actual definition in the individual colour, provided that the full definition is transmitted in brightness, as the eye is much more sensitive to detail in brightness than it is to detail in colour. The effect of this is that it is possible to achieve a definition in colour that is apparently equal to or better than the definition in black and white within a comparable or an equal bandwidth.

Colour Acuity.—The eye can utilise finer detail in some colours than in others, and to achieve the greatest economy in transmission it is important to determine the average variation of this acuity. Tests have been made to determine this acuity using an eye-testing chart projected either in the form of coloured letters on a black background or with black letters on a coloured background. Observations were made with a number of observers at various intensities of light. The results are shown in Figs. 1 and 2. From these we see that at the average brightness of a television receiver (1) the eye perceives much more detail in green and red than in blue; (2) this difference in perception of the three colours tends to disappear as the picture brightness increases; and (3) at low picture intensities the differences between individual viewers are appreciable, but tend to reduce with increasing picture brightness. The conclusion is reached however, that at picture brightnesses likely to be used for normal home receiving it will be possible to transmit less detail in the blue than in the green and red, and hence save some bandwidth. The degree of information to be transmitted in the three colours, and the extent to which it can be reduced is one of the arbitrary but vital decisions that has to be taken in the light of statistical evidence.

Colour Flicker.—By reason of the different eye sensitivity to the various colours, the eye will be conscious of flicker at different light intensities for the various colour components of the picture. The levels of brightness at which the flicker rate becomes perceptible and intolerable have been established for white light, but, so far as is known, the same information is not available for coloured images. Experience in the United States shows that for normal picture brightness a frame repetition rate of 60 per second is quite acceptable, and there seems no real fear that for colour picture brightnesses likely to be used in the United Kingdom a rate of 50 per second would cause serious flicker, and therefore there is no reason to expect that it will be necessary to use a higher frame frequency in colour than in black and white. The most essential requirement for a compatible system can thus be met.

Analysis of Colour Information.—The characteristics of a colour element of a picture can be defined by the brightness and the hue and saturation of the picture element. The hue is the essential property of being coloured, while the addition of white light to the pure colour reduces its saturation. If, therefore, we can transmit parameters defining these quantities in terms of the three suitable primary colours we shall transmit all the required information, which after combination will faithfully reproduce the original picture.

All observers will agree on a true white light, which consists of equal energy on all the colours in the spectrum. The amounts of the three selected colours required to give the effect of white light will vary to a certain extent with the eye of the observer, and will also vary with the wavelengths selected for the primary colours. From an appropriate relative amplitude of these three colours—red, green and blue—we can therefore synthesise most colours to a reasonable degree of approximation, and by regulation of the absolute amplitude we can give any required brightness. In some systems it is convenient to transmit the colour information on a sub-carrier using the complementary colour rather than the direct component. By so doing the amplitude of the sub-carrier signal at full luminance condition is reduced. In all colour synthesis it is important that the linearity of the system is preserved over the whole range of brightness. If the brightness of a hue composed of two colours changes, then the brightness of both components must change in proportion or the hue

* Paper read before Section G of the British Association at Liverpool on Friday, September 4, 1953.

† Deputy Chief Engineer, British Broadcasting Corporation.

will change. This requirement on the linearity of the system is much more rigid in a colour system than in black and white television.

Basic Systems.

The basic problem is therefore either to transmit separate pictures in each of the three colours, or such information as will enable the three colours to be derived. These three pictures may be transmitted in sequence or simultaneously, or in a method which is a combination. If the information is transmitted in sequence then the repetition must be sufficiently high that the eye does not perceive flicker due to alternation of colour images of different brightnesses.

Sequential Systems.—In a sequential system the information to be transmitted is sent in the three colours in a definite time sequence, and each colour is present on the screen for one-third of the total time. The colour sequence may be maintained over the frame period, or from line to line, or from dot to dot along a line. Probably the simplest system is the frame sequential system, where the transmission of the image in a single colour occupies the whole of one frame period. The frame frequency of the system must therefore be three times the frequency of occurrence of any one primary colour. This necessarily means that any system which uses frame sequential transmission must use a colour frame frequency of the order of at least 25 complete interlaced frames per second. It follows that on an interlaced system a frame frequency rate for all three colours must be at least 150 frames per second. This imposes appreciable limitations on any frame sequential method, and renders it incompatible with black and white 50 frame systems.

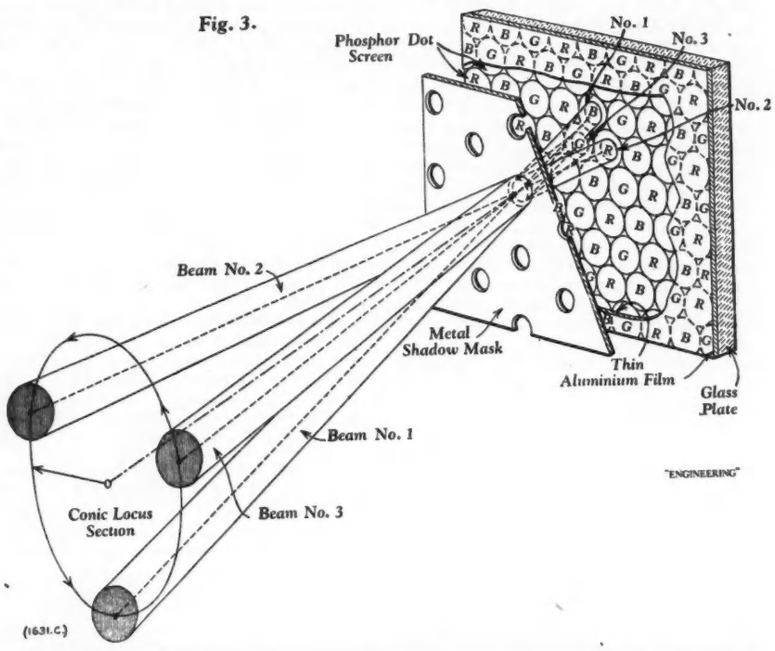
It should, however, be possible to make a material improvement in the situation by transmitting the information in sequence but taking either the line or the dot structure in sequence. Up to the present no successful line sequence system has been developed, although successful dot sequential demonstrations compatible with existing monochrome transmissions have been given.

Simultaneous Systems.—Here the whole of the information in the three colours is sent simultaneously. It would, of course, be possible to do this by transmitting and receiving them independently and combining them optically by the use of devices such as dichroic mirrors. This was the basis of early simultaneous transmission, but it resulted in the usage of three times the bandwidth of a single picture, and resulted in a system that was completely unreceivable by existing types of receiver. This method has now been generally abandoned and search made for a compatible system of simultaneous transmission within the bandwidth limits of existing television transmission (that is, in the United States, within a six megacycles per second channel), and various forms of multiplex working were adopted in order to compress the information.

The first attempts to devise a compatible colour system within the normal video band made use of the fact that the eye can discriminate fine detail in light intensity but is relatively insensitive to fine detail in colour. Economy of bandwidth was therefore achieved by transmitting the individual colour components within a bandwidth value approximately half the total bandwidth, and the mixed highs, which carry the brightness value only of the fine detail, are transmitted in the upper part of the bandwidth. This was the system known as the "mixed highs." On reception, the three separate colour pictures were produced independently and optically combined. Colour television took a big step forward, however, when the Radio Corporation of America produced in 1950 its tri-colour receiving tube. This tube has coloured phosphors applied in triangular dot formation. In 1952 the Lawrence tube, in which the coloured phosphors are in line formation, was produced. Both of these tubes will operate with either a sequential or a simultaneous system, and by avoiding the necessity for any mechanical moving parts offer not only the possibility of a completely electronic solution to the television problem, but also avoid the complexity, cost and limitations of the three separate pictures plus optical combination of the pictures.

COLOUR TELEVISION BROADCASTING.

Fig. 3.



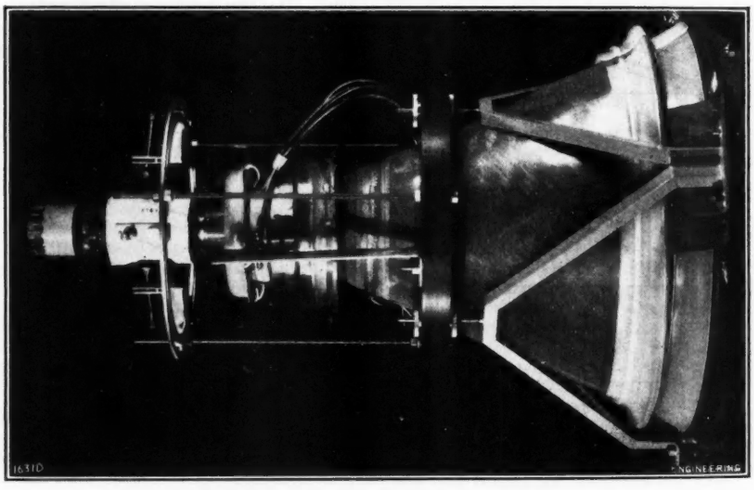


Fig. 4. R.C.A. Tri-Colour Picture Tube.

Bandwidth Requirements.—If information is to be transmitted in the same detail for colour as for a black and white picture, then all television systems would require something approaching three times the bandwidth of a black and white picture unless special systems are used. It may, however, be possible to reduce the definition in the individual colour components, and, by transmitting this colour information within the bandwidth of the black and white picture, reduce the frequency requirements to no more than that which is required for black and white only. Whether this can be done with acceptable arrangements at the transmitting and receiving ends of the circuit is one of the most important questions to be answered. If it can be done, then the system is compatible and existing receivers could obtain a monochrome picture from such a transmission.

Colour Break-Up and Fringing.—In any system of picture projection fast-moving objects will occupy successive discrete positions on the screen at each of the successive frame periods. In black and white transmission these will show up more or less as a blur. In colour transmission such separate images will tend to show up in their separate colours. In the case of frame sequential transmission this effect will be much more marked than in a simultaneous system. This effect too therefore imposes a limitation on the minimum frame frequency, and hence the time interval between successive images, for a sequential system. Simultaneous systems have considerable advantage in these respects.

Systems so far Developed.

If we confine ourselves solely to colour developments in the post-war years there will be time to give only a very brief outline of some of the systems which under present showing might be possible as the basis for a public colour television service. The order of discussing these systems will be more or less the order in which they have been developed, but no other significance should be attached to the order in which they are related. Also it will be appreciated that nearly all systems are under active development at the moment, and hence changes of more or less fundamental nature are possible at any time. Conditions in the United Kingdom are also very different from those in the United States, particularly so in the different standards employed for the existing television transmission, and it is not safe to assume that a system which promises to be

satisfactory on United States standards will be equally satisfactory on United Kingdom standards.

Columbia Broadcasting System.—This system, which so far is the only system authorised in the United States for regular colour transmission, sends images in the three colours in frame sequence. A three-colour filter rotates in front of the camera tube, and usually a similar filter in synchronism with it is rotated in front of the viewing tube. In order to economise in bandwidth, and to come within the six megacycles per second channel while maintaining a sufficiently high flicker rate, the line frequency has been reduced from the American standard of 525 lines to 405 lines. The whole of the object is scanned with half the lines on an interlaced system in $\frac{1}{144}$th second. In $\frac{1}{24}$th second, therefore, the object is scanned with an interlaced signal in each of the three colours. Good colour fidelity is obtained, and with the high frame frequency employed there is only a small tendency to colour break-up. If this system is used with a rotating mechanical filter in front of the viewing tube, a limitation is imposed on the size of the picture, due to the dimensions and speed involved. It is, however, equally possible to use one of the forms of tri-colour tube on this system, in which case the mechanical difficulties are avoided but the difficulties of colour break-up and flicker still remain. A serious objection to the system is, however, that because the frame frequency is so high, transmissions sent out on this system are not receivable on a normal receiver without very appreciable modification. In the United States the Federal Communications Commission granted a licence to the Columbia Broadcasting System to start regular colour television transmissions using this system, but they have recently indicated that they do not propose to go ahead with this system.

Radio Corporation of America System.—The tri-colour tube of this system is shown diagrammatically in Fig. 3, opposite, and has a mosaic of tri-colour dots on the fluorescent screen. These dots, in triangular arrangement, fluoresce in red, green and blue, and are arranged with approximately 900 dots along the line and 650 dots in vertical spacing. At a distance of approximately $\frac{3}{8}$in. from the fluorescent screen is a mask with as many holes in it as there are sets of tri-colour dots, the holes being opposite to the centre of the tri-colour dots. At the cathode end of the tube are three separate cathode-ray guns so aligned that each gun fires through the holes in the mask and hits only one of the three dots; that is to say, the red gun can bombard the red dots only, and so on. The tube therefore can produce three separate pictures, the individual picture elements being so slightly displaced from each other as to be virtually coincident. Final adjustment of the alignment of the beams is made by means of external magnets shown in Fig. 4.

The development of such a tube is a masterpiece of mechanical precision and electronic accuracy. The production of such tubes in the quantities required for a television service and at a cost which will make the system commercially practicable is a very difficult problem. It is, however, understood that appreciable quantities of these tubes have already been constructed. It is also understood that in a further development of this tube a single gun tube has been developed in which electrical deflection of the beam replaces the mechanical displacements of the three-gun tube.

Various methods have been used by Radio Corporation of America for transmitting the colour information within the required bandwidth. Further development in the United States of a compatible electronic system is now being evolved by an association of most of the principal companies interested in colour television. This association is called the National Television Standards Committee and the system they are producing is known as the N.T.S.C. system.

The Lawrence Tube.—The Lawrence tube consists of a fluorescent screen which has alternate strips of coloured phosphor, as shown in Fig. 5. At a distance of approximately $\frac{1}{4}$ in. from the phosphor is a mesh of fine wires which deflect the beam coming from the single gun, so as to strike the green phosphor if not deflected, and either the red or blue phosphor, in accordance with the potential on the mesh, if deflected. This tube can be used for the production of a sequential picture either in the form of a frame sequential picture or in a dot sequential picture whereby the beam is deflected in sequence into the three colours. The power required to deflect the beam will, however, be clearly dependent on the frequency at which the beam is deflected and for the high frequencies involved in a dot sequential system appreciable deflecting energy is required to be delivered to the mesh of wires. It is also possible that a three-gun system might be developed which would enable a simultaneous type of transmission to be received. Good results are said to have been obtained with the tube, but no public demonstrations have yet been given.

The National Television Standards Committee System.—The N.T.S.C. system pre-supposes the use of a tri-colour tube, and defines that it is

Fig. 5.

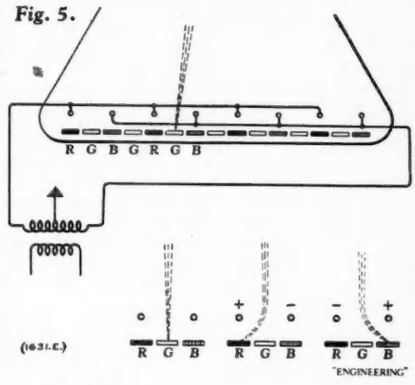
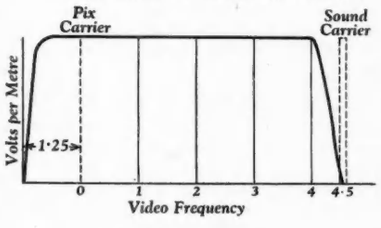
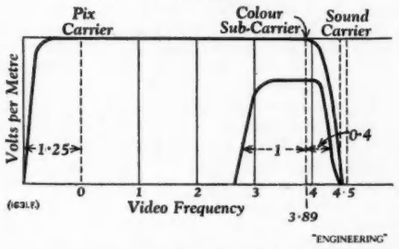


Fig. 6.

(a) STANDARD BLACK AND WHITE.



(b) N.T.S.C. COLOUR.



necessary to transmit the whole of the information within the existing six megacycles per second American television channel, and that the transmission shall be compatible with existing United States black and white television. This it does by transmitting the information in separate quantities: (1) It transmits the brightness component of the monochrome—called the luminance component—in the normal manner and with the normal standards for a monochrome picture. This component is receivable on a normal receiver to give a normal picture, and hence ensures the compatibility of the system. (2) It transmits the colour information, or the so-called chrominance signal, in the form of separate information in two colour co-ordinates. It says that the white light of the luminance picture must be composed of the three separate components corresponding to the three primary colours, and that if therefore two of these colour components are transmitted individually the third is obtainable as the difference between white light and these two separately transmitted components. It assumes that it is possible to transmit the chrominance detail with reduced bandwidth. It recognises that if the colour information is transmitted within the vision band of the brightness signal, then an interference pattern must be caused to the reception of the luminance signal. If, however, this information is transmitted at a fairly large frequency difference from the vision carrier, then the interference pattern will be one of fine detail only; also if the interference pattern is similar in character to the line structure of the picture it tends to become invisible. Moreover, it has been found possible to transmit the colour information within a fairly small frequency band around the sub-carrier frequency, and hence minimise the interference to the monochrome picture.

Fig. 6 shows the radiated signal for a normal monochrome and for a N.T.S.C. colour signal. A black and white receiver disregards the information contained in the sub-carrier of Fig. 6 (*b*) and therefore sees this signal as a normal signal as in Fig. 6 (*a*). The composition of the colour information can be assessed as follows. If in a three-colour camera output E_R, E_G and E_B are equal voltages in the red, green and blue channels, then luminance signal $E_Y = 0{\cdot}59\ E_G + 0{\cdot}30\ E_R + 0{\cdot}11\ E_B$. This luminance signal will approximate to white light. This composition is arbitrary and depends among other things on the wavelength of the colour components.

To produce the chrominance signal two balanced modulations provide outputs modulated respectively in phase and in quadrature with a local sub-carrier. The modulating voltages are colour difference signals. The combined video signal transmits separately the coarse detail—that is, frequencies up to 0·5 megacycle per second—in each of the three primary colours; the medium detail is transmitted for orange and cyan, but the fine detail, i.e., frequencies above 1·3 megacycles per second, is transmitted in black and white only. A burst of a synchronising signal very accurately located with respect to the line signal serves to lock the oscillator which feeds the synchronous demodulators in the receiver and hence gives back the separate colour components delivered to the modulators. The colour difference signals obtained are added separately to the luminance signal for each of the three guns, and hence control the colour content of the picture.

In order to reduce beat frequency patterns with the line pattern it is necessary that the difference between the sub-carrier and vision carrier frequencies should be a multiple of half the line frequency, and that this relationship should be exact. In the N.T.S.C. system at the present time the line frequency is 15,750 cycles per second and the sub-carrier displacement from the vision frequency is 3·579545 megacycles per sec. $\pm$ 0·0003 per cent.

Active development work is still proceeding on this system, and it appears that final details have not yet been fully agreed by the various bodies interested in it. The system does, of course, impose very severe requirements in electrical and manufacturing tolerances, both in the tri-colour tube and in the electrical stability of the circuits used at both the transmitting and the receiving equipments. The circuit complexity of the receiver is considerably increased. It is understood that the total number of valves is increased by about 50 per cent., while the tri-colour tube is naturally considerably more expensive than a monochrome tube. Up to the present no public demonstration of this system has been given. It is impossible, therefore, to forecast whether or when this system will come into service in the United States.

Colour Television in the United Kingdom.—The position in the United Kingdom is that some demonstrations of colour television operating in a sequential non-compatible system have been given. In a number of laboratories development work is proceeding on both the fundamental and the practical aspects of the problem. Consideration is also being given to the utilisation of the wavelengths available. The first report of the Television Advisory Committee has said that they consider that colour television when it comes should be compatible with black and white television.

Effect of Colour on the Transmission System.

Camera Equipment.—The advent of colour transmission will make an appreciable additional com-

plication in the camera equipment in studios. It will be necessary to produce three picture signals in place of one, and to produce these either by a system of rotating colour filters and a single camera tube, or by means of fixed colour filters and one or more camera tubes. In a simultaneous system these three pictures must be accurately registered one with the other. This will mean that the camera will be more complicated and probably somewhat larger than existing cameras; it probably will not, however, make any important difference to the ease with which the camera can be handled. The switching operations between the cameras and the output of the studio will be somewhat more involved and the whole cost of the studio equipment very appreciably increased. It will also have considerable effect on the methods of lighting used in studios, while the uniformity of response to colour of the camera tube and uniformity of characteristics between tubes will become very important.

If one of the simultaneous systems using a sub-carrier is employed, then it will be necessary to lock together the sub-carrier frequency, the line and frame frequency, and the timing of any colour synchronising pulse frequency. This will mean that the present practice in the United Kingdom of tying the line frequency to the mains frequency will have to be abandoned. This latter would represent very little difficulty from the transmitting point of view, but might give trouble in some receivers which would be required to take a monochrome signal from the colour transmissions. Colour would involve an appreciable increase in the complexity of the studio operation, but if a method could be evolved to meet the other requirements of transmission, and, most important, those of reception, then the complexities and the cost in the studio would be readily accepted.

Lines.—The largest single recurring cost in a television broadcasting system such as exists in the United Kingdom is the cost of the lines or radio links connecting the studios with the various transmitters, or outside broadcast points, with the studios. With a non-compatible sequential system it would seem probable that a colour signal could be transmitted over existing or similar networks with no appreciable modification or increase in cost. A compatible simultaneous system, such as the N.T.S.C. system, implies, however, that a very close tolerance must be maintained on the timing of the various carriers and pulses, and hence all parts of the transmission system must have a very small distortion in terms of amplitude and phase delay over the whole of the video band. Moreover, the effective bandwidth of the video signal is increased. These requirements will involve considerable difficulty and cost.

Transmitting Equipment.—Assuming that it is possible to transmit a satisfactory colour signal within the existing bandwidth, then for a sequential system very little modification of the transmitter will be required. If, however, it was necessary to transmit the whole or a part of the colour information outside the channel or band, then additional transmitting plant would become necessary. As is the case in the line system, the transmitter with its associated sound and vision combining circuits, transmission lines and aerial, must bring in negligible distortion of the various components of the colour picture in either amplitude or phase over the wider frequency band involved. Here again appreciable increase in difficulty and cost will result.

It is possible that colour may affect the range of a transmitting station in that the limit of useful service area on colour will be appreciably less than the established range of monochrome reception. This limitation may be caused by differential fading or attenuation of the various components of the picture. To cover a given area may therefore mean that more transmitters, and hence more channels will be required. This may prove a serious matter for the establishment of a nation-wide colour television service.

Effect of Colour on Receiving Equipment.

Existing Sets.—The advent of colour would cause owners of existing sets to ask two questions: (1) Will it be possible to modify my receiver so as to make it capable of reproducing a coloured picture? (2) Will it be possible for my receiver, without any modification, to reproduce a monochrome picture from a colour transmission signal? The answer to both these points is entirely dependent on the decision as to the system of colour television transmission to be adopted. If a sequential system is adopted it would be possible, although perhaps not easily practicable, to fit a mechanical adaptor incorporating a rotating colour filter to an existing design of television set, and to make the necessary modifications to the circuits so that the receiver could receive a colour picture. The receiver could be arranged so that it could also, if required, be switched back to normal operation for receiving a monochrome picture from a monochrome transmission.

If a simultaneous and compatible system is employed, then the amount of modification involved to obtain a colour picture would be so great as to be quite impracticable. It would, however, be possible for the owner of an existing receiver to continue to receive a monochrome picture from a colour transmission without modification.

It must be realised, however, that evolution of a successful compatible simultaneous system in the United Kingdom is likely to bring in some problems of even greater difficulty than those met by the N.T.S.C. in the United States. The fact that the channel width is narrower means less space between the carriers and sub-carriers involved, and hence greater difficulty in their separation without amplitude or phase distortion. Very important, however is the fact that in the United Kingdom the sound channel is amplitude modulated, and hence the separation of the chrominance sub-carrier may be more difficult than is the case in the United States where the sound carrier is frequency modulated.

New Sets.—Whatever the form of colour transmission which may be adopted, it would seem probable that it would not have any very great influence on the overall size of the set, which is largely dependent on the size of the cathode-ray tube employed. If a sequential system were adopted it would be possible to use fairly small cathode-ray tubes to give colour pictures with the aid of a rotating colour filter, and larger pictures by the use of tri-colour tubes or by the use of projection type tubes.

If a simultaneous system is employed it would most likely entail the use of tri-colour tubes although the use of three separate tubes of either the direct or the projection type, with subsequent optical combination, cannot be ruled out. The cost of the tri-colour tube must necessarily be appreciably greater than the cost of a monochrome tube of the same size, and the valves and circuitry associated with the receiver would also cost appreciably more. It is, however, at the present time, very difficult to say by how much the cost of the colour receiver would exceed that of a similar size monochrome receiver. Statements have been made in the United States to the effect that 17-in. colour television receivers will be initially available at costs from 800 to 1,000 dols., and that these costs should fall as receivers come into production. By reason of the greater number of valves and the complexity of the circuits involved, the service cost is likely to be appreciably greater.

Stability of Receivers.—All receiving tests on colour television systems so far have been carried out under laboratory or restricted field-test conditions. A colour television receiver requires a much greater stability of all circuits and components, and stability of receiving conditions. The limitations such variations may impose on faithful colour reproduction have still to be assessed. In monochrome transmission we know that we can get sufficiently good reception up to distances of the order of 50 miles from the transmitting station. On a colour system, particularly a simultaneous sub-carrier system, it may, however, be that some form of differential fading and reflections at these distances may so seriously distort the colour information as to impose a serious limitation on the range of colour reception. All this has to be verified by very considerable experimental work, and may affect very seriously any scheme for colour distribution systems. There is therefore very much experimental and planning work required before a comprehensive colour television plan for the United Kingdom could be put forward.

General Requirements for a Colour Television System for the United Kingdom.

The requirements to be met by a colour television system for the United Kingdom will no doubt be decided by the Government on the advice of the Television Advisory Committee, which has already recommended that any colour system to be employed in the future should be compatible in the sense that the colour transmissions should be receivable in monochrome on receivers not designed for colour. It will still be necessary to decide on the details of the system to be used, and it will be necessary to decide whether all the colour information can be transmitted within the limitations of a five megacycles per second channel, or whether it will be necessary to send colour information outside such a channel. The actual details of the system, taking due regard for cost and complexity of the viewer's receiver, will still have to be settled.

This paper has done no more than touch on some of the problems confronting the Government, the operating authorities, and the radio industry and the public in the introduction of colour television. The problems are technical, financial and economic and all must be solved, or at least be seen in full perspective, before a public service can be instituted and be a success. It is fairly clear that at this point in time, when this country has not yet been completely covered with a monochrome television service, it will be a matter of years before colour television in the home is likely to be a reality.

DIATOMITE INDUSTRY IN THE ISLE OF SKYE.

Diatomite is used for heat-insulating materials, as a filler for paints and rubber, and for the filtration of beer and other beverages, penicillin preparations, sugar, etc. A large deposit of diatomite, estimated to be of one million tons, is now being worked in the Isle of Skye by Scottish Diatomite, Limited, in conjunction with William Kenyon and Sons, Limited, Dukinfield, Cheshire. Diatomite is of cellular formation and consists of the siliceous remains of small organisms deposited at the bottom of water over tens of thousands of years ago. It is normally imported into Britain, to the extent of 25,000 tons a year, from the continental countries, the United States, and East Africa.

The deposit now being worked was previously worked some 50 years ago (at a time when Britain was independent of foreign exchange), and it lies in the bed of what was Loch Cuithir, now drained of its water. To obtain access to the deposit, a road was constructed up to the Loch, which is on the north-east side of the island, by the Department of Agriculture for Scotland. A ditch surrounding the loch was constructed to intercept the drainage, and to serve as a discharge channel into which the waters of the loch were pumped. The bed of the loch is now dry, and the deposit, which covers approximately 25 acres, is laid bare. In order to process the material, which, although of high quality, has to be free of all impurities and of a high degree of fineness, a factory has been erected on the coast at Uig, 24 miles from the deposit, where shipping facilities are available. This processing plant was formally opened by the Rt. Hon. the Earl of Home on September 30, marking the culmination of four years of effort to win this valuable material from beneath the waters of an isolated loch set among barren surroundings.

A Large Universal Testing Machine.—What is claimed to be the largest universal testing machine yet built is to be installed in the Fritz Engineering Laboratory of Lehigh University, Bethlehem, Pa., U.S.A. It is being constructed by Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa., U.S.A. It will have a capacity of 5,000,000 lb. in tension, compression or bending. Two other machines of this capacity have already been made by this firm, but they will not admit such large test-pieces. The new machine will have a total height of 57 ft. with a clear space 40 ft. high and 10 ft. between columns. The floor of the laboratory is being constructed to allow the transverse testing of structures up to 40 ft. long, which will pass through the opening of the machine. Loads will be applied by a hydraulic cylinder 54 in. in diameter and with a stroke of 36 in. The maximum rate of travel of the ram is 3 in. per minute.

ELECTRONICS IN THE SWITCHING OF TELEPHONE CALLS.*

By L. J. MURRAY, B.Eng. (Hons.), A.M.I.E.E.

(*Concluded from page* 415.)

IT is now proposed to describe some of the more interesting electronic control circuit elements. The most generally used type of tube in the circuits which follow is the cold-cathode triode and this is used because of its value as a simple triggerable element which does not require any expenditure of power in heating. In Fig. 6 (*a*) if the anode to cathode voltage is not high enough to fire the tube of itself, but is high enough to maintain the discharge once it is started, then a voltage applied at the trigger electrode sufficiently positive to break down the trigger-cathode gap will cause the tube to conduct in the main or anode to cathode gap, providing the trigger voltage is maintained long enough to cover the time required to transfer the discharge from trigger gap to main gap. Since this is of the order of 30 to 100 microseconds in a suitable tube, it follows that narrow-width positive pulses of sufficient voltage can be used to control the operation of the various tubes. If the tube of Fig. 6 is fired by such a pulse, the discharge between anode and cathode will cause a sharp rise in voltage across the cathode resistor R and this is used as the output to control a further tube or tubes in the circuit. It is often convenient to apply the triggering voltage in two stages—prime and pulse. This allows circuit technique to be used in the selective firing of one tube, but is caused first to fire a cold-cathode diode as shown in Fig. 6 (*b*), the conduction of which causes the necessary rise in potential for the output voltage. The diodes are used in these cases for isolating purposes, particularly where two or more tubes control one dependent circuit.

Line-Scanning Circuit and Subscriber's Line Circuit.—The scanner includes three multi-cathode, high-speed cold-cathode tubes, for units, tens and hundreds counting respectively. These are of the

Fig. 6. (*a*)

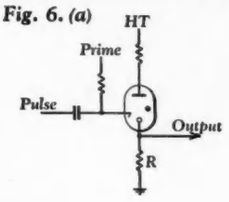


Fig. 6. (*b*)

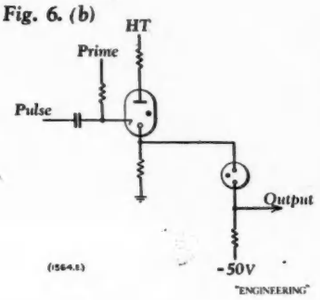
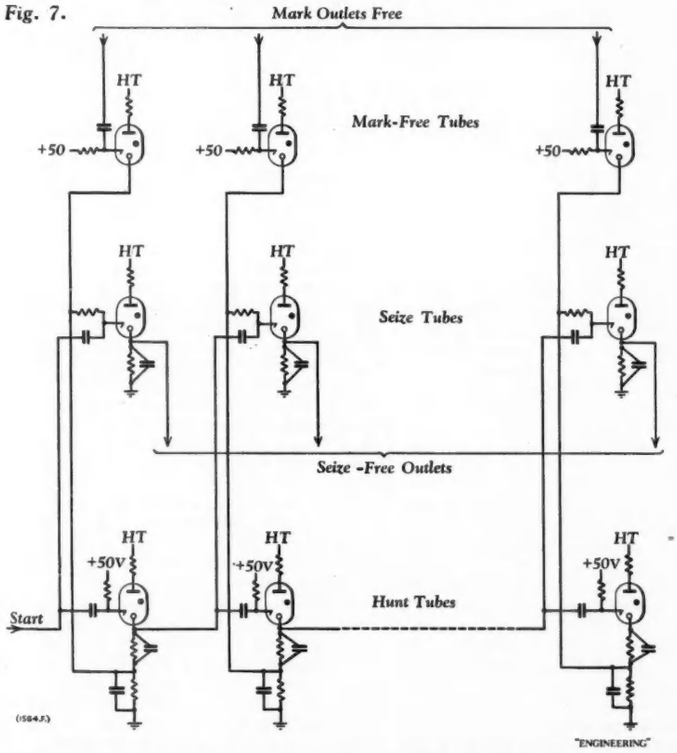


Fig. 7.



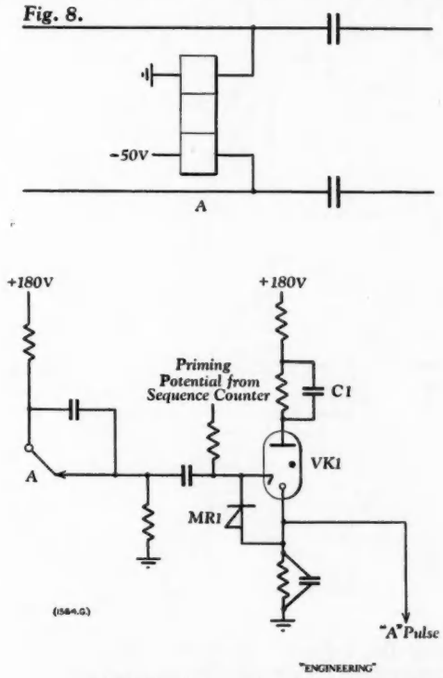
of a group of tubes, whereby the application of a pulse in common to all the tubes results in the firing of only that one which has been previously primed. In another application, a co-ordinate technique may be used in which one set of tubes all have their triggers primed while an intersecting set have a pulse applied. Only the tube common to both sets will receive both a prime and a pulse voltage and will therefore conduct.

In some cases it will be noted that the output is not taken directly from the cathode to a succeeding type having a single anode and in which commoned transfer electrodes are interposed between the separate cathodes, so that a sequence of negative pulses, applied to the common transfer terminal, advances the gas discharge from cathode to cathode, giving a positive output pulse at each cathode in turn. The units counter has 10 cathodes and is driven from a main pulse source at 4,000 steps per second. The tens counter has 10 cathodes and is driven from the units counter at 400 steps per second. The hundreds counter has five cathodes and is driven from the tens counter at 40 steps per second. A complete scan of the 500 lines in one group takes 125 milliseconds and in that time there is fed once into each subscriber's line circuit a coincident set of three output pulses from the units, tens and hundreds counters, suitably amplified and/or inverted as required. If the subscriber is not using his telephone, or is already connected to the exchange, these pulses have no effect. If, however, he has removed his telephone to call, they cause a set of cold-cathode triodes and diodes individual to the line circuit to give marking signals to the common control to initiate the connection of the line to a free transmission relay set. When this has been done a cut-off relay operates to disable all tubes in the line circuit until the subscriber replaces his telephone at the end of the conversation.

High-Speed Hunting Circuit.—The purpose of this circuit, shown in Fig. 7, is to select and seize the first free outlet in a group. Each outlet has three cold-cathode tubes designated respectively "mark free," "seize," and "hunt." A free outlet has its mark free tube conducting and supplying from its cathode a priming potential to its seize tube and a backing-off potential to its hunt tube. Hunting commences with a positive pulse appearing on the start wire. If the first outlet is free, the seize tube fires and a pulse voltage appearing at its cathode initiates circuit operations in the seized outlet. If the first outlet is not free its hunt tube, being primed and not backed-off, fires and extends a pulse from its cathode to the seize and hunt tubes of the next outlet. If this is free, the seize tube fires and the outlet is seized. If not, the hunt tube fires and extends the pulse to the third circuit, and so on until a free outlet is seized.

At the end of the hunting, there may be several hunt tubes remaining conducting. These are extinguished by removing the H.T. in the common

Fig. 8.



control circuit searching for a free outlet. The triggering of the mark free tube and the H.T. supply for the mark free and seize tubes are controlled by the outlet with which they are associated.

Transmission of Impulses from Subscriber's Dial to Register.—When the calling line is connected to the transmission relay set the relay A, Fig. 8, operates in series with the subscriber's telephone. When the subscriber dials he breaks the circuit at 10 impulses per second according to the digit dialled. Relay A releases at each break and upon each re-make of its contacts applies a positive pulse to the already primed trigger of cold-cathode tube VK1. This is connected as a self-extinguishing pulse repeater in which after the anode/cathode gap has been triggered by the third electrode in the usual way, the charging of capacitor C1 reduces the anode potential until it is no longer capable of

* Paper read before Section G of the British Association, at Liverpool, on Friday, September 4, 1953. Abridged.

SWITCHING OF TELEPHONE CALLS.

Fig. 9.

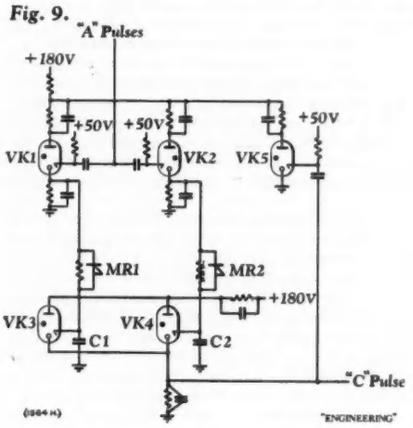


Fig. 10.

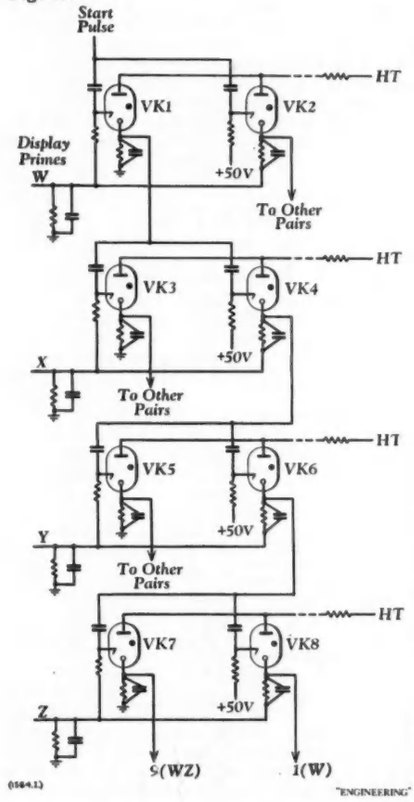
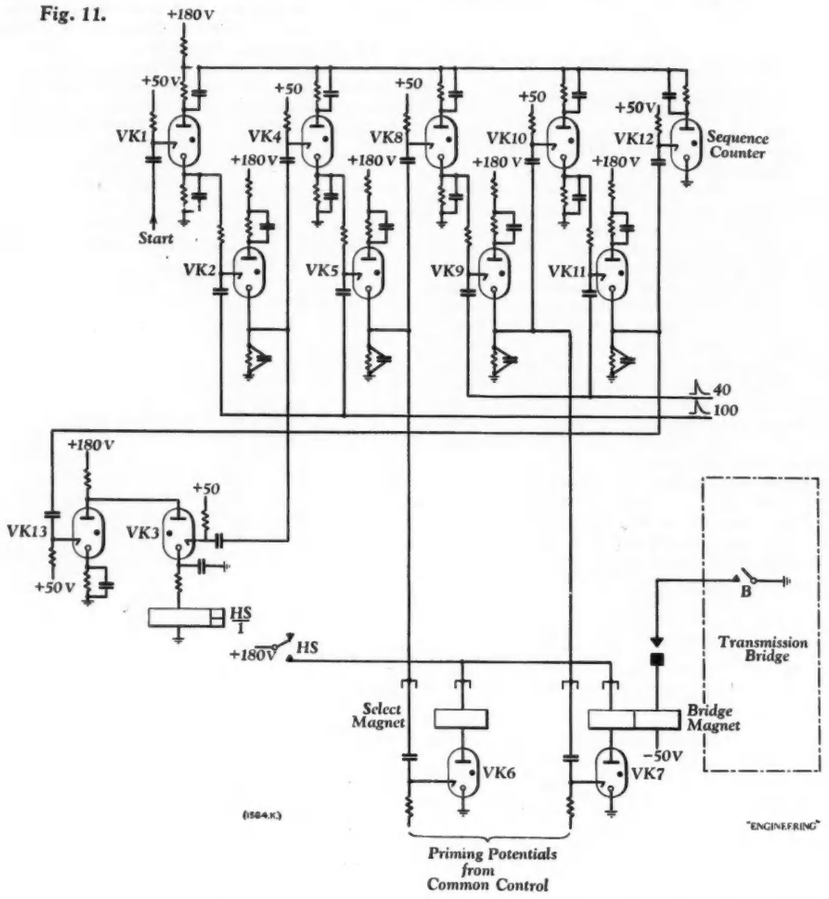


Fig. 11.



maintaining the discharge. The time constants of the circuit are such that the tube remains conducting for such a period as to send a positive pulse from its cathode into the register. The number of pulses so derived from the cathode is the same as the digit dialled. After each digit the A relay remains re-operated.

The rectifier MR1 shunts the negative pulses which occur when relay A re-makes and prevents them triggering the tube in the reverse direction at the end of each impulse.

Counting and Storing of Subscriber's Dial Impulses in Register.—The digits dialled by the subscriber are sent by the transmission relay set to the register as A pulses derived as shown in Fig. 8, and are there counted and stored in a binary arrangement. At the end of the train of "A" pulses representing a digit, a combination of 1, 2, or 3 of a set of 4 cold-cathode tubes, which may be referred to as W, X, Y, Z, remains operated according to the digit as indicated in Table I.

TABLE I.

Digit.	Tubes.
1	W
2	X
3	W, X
4	Y
5	W, Y
6	X, Y
7	W, X, Y
8	Z
9	W, Z
0	X, Z

Also at the end of the digit, a C pulse, derived from Fig. 9, causes a corresponding set of storage tubes to be operated, and resets the counting for the next digit.

"C" Pulse Circuit.—The C pulse, see Fig. 9, indicates the finish of a digit and its generation depends upon the fact that the normal period between the A pulses of one digit is of the order of 66 milliseconds. A period greater than this indicates that the digit is complete. The tubes VK1 and VK2 form a binary pair fired alternatively by the A pulses. Firing potentials for the triggers of the delay tubes VK3 and VK4 are obtained from the cathodes of VK1 and VK2, respectively, but the charging time of the condensers C1 and C2 is such that VK3 and VK4 cannot fire during the interval between pulses in a digit. Either VK3 or VK4, however, fires during the interval between digits, and gives the C pulses from its cathode. VK5 fires to the C pulse and restores the circuit to normal at the end of each digit. Rectifiers MR1 and MR2 prevent the voltage across the condensers C1 and C2 building up during impulsing and thus avoid the danger of tubes VK3 and VK4 striking during a long train of impulses.

Storing of Digits and Conversion from Binary to Decimal.—There is a storage group of four cold-cathode tubes for each digit, see Fig. 10, and a sequence counter stepped between digits by the C pulse causes a counting circuit to transfer each digit, in turn, to its appropriate storage group. In transferring the called number from the register to the group selector common control the digits are converted from binary storage to decimal in the manner shown in Fig. 10. The storing of a digit in binary form results in a priming potential being placed on one or more of four digit marking wires designated in Fig. 10 as W, X, Y and Z. One pair of conversion tubes VK1 and VK2 is associated with the W wire so that a positive priming condition on this wire, when accompanied by the application of a positive start pulse to the circuit, will strike VK1 and back-off VK2, while the absence of this priming condition when the pulse is applied will strike VK2.

The pulse produced at its cathode by the firing of VK1 is applied to another pair of tubes VK3 and VK4, of which VK3 may be primed by a positive voltage on wire X, while VK4 is permanently primed but is backed off by the marking on wire X. Thus, if VK1 fires, VK3 or VK4 will fire according to whether the wire X is marked or not. In a similar way, two other tubes (not shown) operate to a pulse from VK2 and a marking on X wire. For a pulse on the start wire, therefore, any one of four tubes will deliver pulses dependent upon whether either the W wire, the X wire, or both, or neither, are marked. These four pulses are applied to four pairs of tubes, of which one only (VK5 and VK6) is shown, which in conjunction with a marking on non-marking on wire Y, will produce one pulse of a possible eight, depending upon the possible combination of marking on the W, X and Y wires. Finally, a marking or non-marking on the Z wire may combine with one of these possible eight pulses to give an output from one of 16 tubes of which only VK7 and VK8 are shown. There are 16 possible combinations of

markings on wires W, X, Y, Z, but since we are only concerned with decimal numbers only ten of them are used, and only the corresponding ten tubes in the final stage of the converter are used. Fig. 10 shows how digit 1 (storage condition W only marked) is given as a decimal output by the operation of tubes VK1, VK4, VK6, and VK8, and digit 9 (W, Z) by the operation of tubes VK1, VK4, VK6 and VK7.

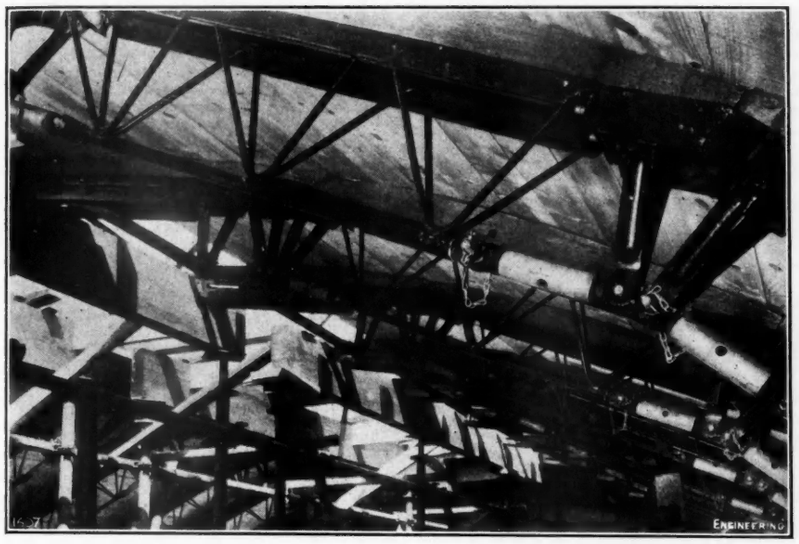
Operation and Holding of Crossbar Switch Magnets.—The select and bridge magnets to be operated in a crossbar switch for a given connection, see Fig. 11, opposite, are determined by the appropriate common control upon the selection of a path. The common control applies a priming voltage to the operating tubes, such as VK6 and VK7, of the chosen magnets. The arrangement of the crossbar switch mechanism requires that the select magnet energisation precedes that of the bridge magnet by a period sufficient to allow for its full operation. To control these operations the switch control associated with each crossbar switch includes a sequence counter, which is shown in Fig. 11. When the tubes VK6 and VK7 are primed, a positive starting pulse is applied to the sequence counter to fire tube VK1, which primes the pulse-repeating tube VK2, which is itself pulsed at 10 millisecond intervals. When VK2 conducts, tube VK3 fires to operate a high-speed relay which connects HT to the operating tubes such as VK6 and VK7 of all magnets of the switch. VK2 conducting also causes tube VK4 to fire and prime the pulse repeating tube VK5, and in turn this fires on the next occurring positive 100 per second pulse. Tube VK5 applies a pulse to all select magnet operating tubes of the switch but only operates the one, such as VK6, which has already been primed. The conduction of VK6 causes the select magnet to operate. Tube VK5 also causes VK8 to strike, and this, in turn, primes pulse repeating tube VK9, which is also pulsed from an external source, but this time at 25 millisecond intervals. At the next succeeding pulse VK9 firing applies a pulse to the operate tubes of all bridge magnets of the switch, but only operates the one, such as VK7, which has been primed. The conduction of VK7 causes the bridge magnet to operate and the delay which has been introduced by pulse repeater VK9 gives ample time for the select magnet to have completed its operation before the bridge magnet is energised. The firing of VK9 also fires tube VK10, which primes the pulse repeating tube VK11, which is also pulsed at 25 millisecond intervals. After another 25 millisecond delay, therefore, VK11 fires to fire tube VK13. By virtue of the common anode resistor, VK3 is extinguished and relay HS releases, thus removing HT from the magnet operating tubes and allowing the select magnet to release. The bridge magnet holds over a seconding winding to which earth is applied through its own operated contacts, and it remains operated until a clearing signal by the subscribers removes the earth. The delay introduced by pulse repeater VK11 guards the switch against intrusion until the magnet operations are completed. The firing of pulse repeater VK11 fires tube VK12, which is self-extinguishing, and the sequence counter is thereupon restored to normal.

Conclusion.—Although it is probable that electronic methods will play an important part in future telephone switching, the actual extent and manner of their use is still a matter of some uncertainty. To illustrate the use of electronic methods in controlling the switching of calls, one system using such methods has been described, but it is not claimed that this necessarily indicates the direction of final progress.

Acknowledgments are due to the Automatic Telephone and Electric Company, Limited, for permission to use material included in this paper.

SUPPORTS FOR CONCRETE SHUTTERING.

BLAW KNOX, LTD., LONDON.



SUPPORTS FOR CONCRETE SHUTTERING.

THE support of shuttering for reinforced-concrete slabs for floors and roofs during the placing of the concrete is a common problem usually solved by making the best use of available material such as timber, joist sections, or scaffold tubes. Although this material may only be in use for a limited period, it is nevertheless not available for other work meanwhile and, so far as timber and joists are concerned, may receive treatment detracting from its subsequent utility. Equipment designed specifically for this purpose is the "Hico Falsework Centering" now being marketed by Blaw Knox, Limited, 90-94, Brompton-road, London, S.W.3. Basically, Hico centring consists of lightweight girder sections which, by the aid of a variety of end fittings, can be adapted to a wide range of work. The general form of the equipment is shown in the accompanying illustration.

The basic unit consists of a trussed girder, weighing 25 lb. per yard run, having a top width of 6 in., and is available in three lengths—24 in., 37 in., and 49 in. At one end, the lower tension bar is fitted with a turnbuckle so that, when a number of the units have been erected in line, the resultant girder can be prestrained to form a small initial camber in the slab. For constructing normal flat ceilings, the makers provide terminal sections, the effective lengths of which can be varied between 18 in. and 25 in., and form suitable springings for carrying the girders off brick walls. Alternative terminal units permit the girders to be supported off the lower flanges of floor beams.

The adaptation of the system to the construction of barrel-vault roofs is effected by the use of suitable angle members between the ends of the girders. These members are available for angles of either 18 deg. or 5½ deg.; those in the illustration are 18 deg. units being used on a roof having a radius of 15 ft. The true curve of the roof is obtained by inserting timber turning pieces above the chord line obtained with the Hico units.

The units provide a lightweight system of centring easily and speedily erected by more or less unskilled labour without the aid of plant. The units have a high load capacity and, when used at 3 ft. centres, the sections can be combined to give support to falsework over spans of any length between 39 in. and about 27 ft. With reasonable care, the units should show little or no wear, so that there need be little depreciation in value with repeated use.

THE LATE BARON WESTWOOD OF GOSFORTH.—We regret to record the death of Baron Westwood of Gosforth, which occurred at his home in Newcastle-upon-Tyne on September 13. William Westwood, who was for many years a leading official of shipbuilding trade unions, and was raised to the peerage in 1944, was born at Dundee on August 28, 1880. After a brief elementary-school education, he started work in a jute mill at 10 years of age. Later, however, he served his apprenticeship to shipbuilding in Dundee, and, in 1913, was made supervisor of the Shipconstructors' and Shipwrights' Association. In 1929 he became general secretary of the Association and continued in this capacity until his retirement in 1945. From 1933 until 1936 he was President of the Engineering and Shipbuilding Trades Federation, and from 1936 until 1939, was President of the Confederation of Shipbuilding and Engineering Unions. In 1940 he was appointed principal labour adviser to the Admiralty and served as director of contract labour, Admiralty, in 1941 and 1942 and as chief industrial adviser to the Board of Admiralty from 1942 until 1945. Lord Westwood was a Lord-in-Waiting to King George VI from 1945 until 1947. He was a Liveryman of the Worshipful Company of Shipwrights, a Freeman of the City of London and President of the Institution of Engineering Draughtsmen and Designers, with the aims and objects of which he associated himself energetically, although the Institution has no trade-union connections. Lord Westwood was made an O.B.E. in 1920 and was a Justice of the Peace for Northumberland. He was also a Fellow of the Royal Society of Arts and of the Royal Empire Society.

DEFINITIONS OF ELECTRICAL-POWER TERMS.—Recommended definitions of the terms used in power system studies have been drawn up by the British Electrical and Allied Industries Research Association for submission to the British Standards Institution with a view to their inclusion in a British Standard glossary. These definitions, which include load and load-response terms, stability terms and terms relating to symmetrical components, synchronous machines, transformers and lines and cables, as well as governor characteristics, are published as Technical Report V/S1, which is available at a price of 15*s.* from the Association at Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

COLD-CATHODE FLUORESCENT STREET LIGHTING AT LIVERPOOL.—The lighting scheme which is now being introduced at the Pier Head, Liverpool, is believed to be the first to employ vertical cold-cathode fluorescent lanterns for street lighting. These lanterns, which were manufactured by the General Electric Co., Ltd, Kingsway, London, W.C.2, have been designed for mounting on the top of 24-ft. columns, at a spacing of from 100 ft. to 150 ft. They house five 67·5-watt tubes of U-form, the light output being equivalent to that of a similar lantern employing four 5-ft. 80-watt hot-cathode tubes or a 400-watt mercury lamp. The average life of the cold-cathode tubes is 15,000 hours and their output is 35 lumens per watt. The lantern is built round a central steel tube, which is screwed into a spigot cap at the lower end and carries a detachable finial at the upper end. The top of the cap is enlarged to the full diameter of the lantern and carries the operating transformers, which are protected by an aluminium case. There is a Sorbo-rubber gasket in a channel in the upper end of the case which forms a seating for a reeded opal Perspex cylinder. The tubes are secured in glass insulated clips, which are mounted on two spiders.

NOTES ON NEW BOOKS.

Mass Spectroscopy in Physics Research.

National Bureau of Standards Circular 522. The Superintendent of Documents, U.S. Government Printing office, Washington 25, D.C., U.S.A. [Price 1·75 dols.]

This collection of papers constitutes the proceedings of a Conference held at the National Bureau of Standards in September, 1951, as one of a series of 12 symposia commemorating the semi-centennial of the Bureau. Most of the leading specialists in the physical aspects of mass spectroscopy in the United States, as well as those from ten other countries, attended the conference. In addition to the 35 papers, all of which are reprinted here, it has been possible to include a fairly complete record of the discussions that followed the reading of them. The first, and longest, communication, by J. Mattauch on "Precision Mass Spectroscopy and Theory of Dispersion" is, despite some obscurity in the English, an important but largely mathematical survey. It is difficult to discern any scheme in the ordering of the papers. Various mass spectrometers are described and illustrated. Among them are a double-focusing type; a non-magnetic radio-frequency type which can be made so light and compact that it is proposed to install it in a rocket for the direct measurement of the composition of the upper atmosphere; a time-of-flight instrument, especially useful for heavy masses; a parabola spectrograph and the mass synchrometer. Problems affecting operation are dealt with in contributions on electron and ion optics, effect of stray fields in focusing, high resolution, effects at higher pressures and influence of space charge. Applications of interest are to the study of nuclear shell structure and nuclear reactions, and to the measurement of traces of uranium and lead in minerals and meteorites. Results reported relate to the present status of isotopic abundances, mass spectra of heavy hydrocarbons, mass-spectral patterns of isotopic molecules, and studies in solids. Two papers are devoted to the electromagnetic separation of isotopes and two others to the accuracy of isotope mass measurements and to substandards of atomic mass. In the closing session, arranged by A. O. C. Nier, on experimental methods, special attention was paid to electron multipliers in mass spectroscopy.

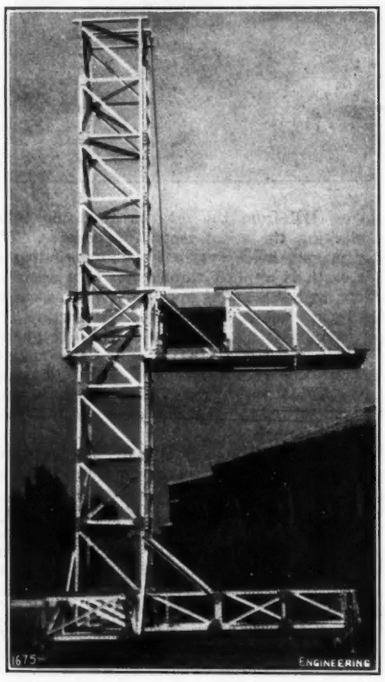
British Regional Geology, Northern England.

Third Edition. Department of Scientific and Industrial Research, Geological Survey and Museum. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*s*. net.]

The region covered by this 70-page handbook of regional geology includes the whole of Northumberland, Durham and Cumberland, most of Westmorland, the Furness district of Lancashire, a little of North Yorkshire and also the Isle of Man. Since the publication of the second edition in 1936, additional information has become available regarding the coal measures on both sides of the northern Pennines and on the Permian evaporite deposits of Durham, and some of the results of these recent investigations are incorporated in the third edition. An introductory chapter deals with the physiography and geological history of the area and there is a short section on the economic products. It is not generally known that, in addition to coal and iron ores, there are sizeable ore deposits of lead, zinc and tungsten, and at one time there was a thriving copper industry at Keswick and at Coniston. Important non-metallic minerals include barytes, witherite, fluorspar, gypsum, anhydrite and salt. Considering the many and varied economic products obtained from the area, it is somewhat disappointing that so little reference is made to them. Succeeding chapters give a concise account of the distribution and characteristics of the geological systems found in the north of England, ranging from the Ordovician to the Pleistocene system. The handbook is well illustrated and it includes a comprehensive list of additional maps and publications on the general geology and mineral resources of the district.

ADAPTABLE STAGING UNITS BUILT FROM STANDARD ALUMINIUM-ALLOY PARTS.

Staging units for facilitating access to aircraft, structures, buildings, etc., are readily built up from a range of standard aluminium-alloy parts now being made by Aero Controls, Limited, Industrial Estate, Weedon-road, Northampton. The parts are being produced under a manufacturing licence from the Patents Exploitation Department of the Ministry of Supply. Standard commercial aluminium-alloy angle extrusions of $1\frac{3}{4}$ in. by $1\frac{3}{4}$ in. by $\frac{1}{8}$ in. section are used. This section is used for the fabrication of four sizes of welded rectangular frame and eight different lengths of simple strut and cross-bracing members, which are perforated at 2-in. centres to accommodate the standard $\frac{7}{16}$-in. nut and bolts used for assembling. In addition to these basic elements, a range of angle brackets, corner braces and gussets are also provided, as well as a



set of combined wheel and jack units which enable a structure or a set of parts to be moved about easily. Variable-level staging is readily constructed, using roller units and a hoist which are included in the set of parts. An example is shown in the accompanying illustration: the 30-ft. mobile tower carries a cradle which can be raised and lowered by a winch. The platform of this cradle measures 6 ft. by 4 ft. and it will support four men.

Although primarily designed for the aircraft industry, and to provide mobile or fixed variable-staging units to enable work to be carried out on aircraft of many different sizes and shapes, this equipment has a much wider field of application; for example, in the building industry. A feature of the system is that erection can be carried out by unskilled or semi-skilled labour, while the components themselves take up very little space; the 30-ft. variable platform tower illustrated, when dismantled, can be packed into a crate measuring 34 in. by 34 in. by 32 in., the crate itself being made up from the standard rectangular frames, and if the standard wheels are fitted the whole set of components can be moved about. Since aluminium-alloy sections are used, each component is light and easily handled, and any structure made up is easily moved from place to place. The components can also be used for constructing work benches, stairways, etc. The triangulated design, which the illustration shows, ensures adequate strength.

BOOKS RECEIVED.

Tyre and Wheel Standards for Cars, Commercial Vehicles, Cycle and Motor Cycle.—The 1953 Edition now published cancels all previous editions. It contains the only current authoritative information on this subject. The Technical Department, Society of Motor Manufacturers and Traders Limited, 148, Piccadilly, London, W.1. [Price 17*s*. 6*d*.]

Chemical Process Machinery. By Professor Emil Raymond Riegel. Reinhold Publishing Corporation, 330, West 42nd-street, New York 36, U.S.A. [Price 12.50 dols.], and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 100*s*. net.]

Aluminum in Iron and Steel. By Samuel L. Case and Kent R. Van Horn. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 60*s*.]

Watch and Clock Making and Repairing. By W. J. Gazeley. Heywood and Company, Limited, Tower House, Southampton-street, London, W.C.2. [Price 42*s*. net.]

Concrete Engineers' Handbook. The Concrete Association of India, 1, Queen's-road, Bombay. [Price 5/8 Rupees.]

The Performance of Circular Plate Ripsaws. By H. J. Endersby. Forest Products Research Bulletin No. 27. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. 9*d*. net.]

Fractional Horsepower Motors. Case Study Data on Productivity and Factory Performance Prepared for the Mutual Security Agency Productivity and Technical Assistance Division by United States Department of Labor. Mutual Security Agency, Washington 25, D.C., U.S.A., and British Institute of Management, Management House, 8, Hill-street, London, W.1. [Price 10*s*.]

Measurements of Atmospheric Noise at High Frequencies during the Years 1945-1952. By F. Horner. Radio Research Special Report No. 26. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s*. 9*d*.]

Elektrische Maschinen. Vol. 2. *Synchronmaschinen und Einankerumformer.* By Professor Rudolf Richter. Second edition. Verlag Birkhäuser, Elisabethenstrasse 15, Basle, Switzerland. [Price 46.80 Swiss francs.]

Transactions of the Institution of Civil Engineers of Ireland. Session 1952-53. Vol. 79. Offices of the Institution, 35, Dawson-street, Dublin.

Fuel Testing. Laboratory Methods in Fuel Technology. By Dr. Godfrey W. Himus. Leonard Hill, Limited, 9, Eden-street, London, N.W.1. [Price 25*s*.]

The World's Great Bridges. By H. Shirley Smith. Phoenix House, Limited, 38, William IV-street, London, W.C.2. [Price 15*s*. net.]

Thermodynamics Applied to Heat Engines. By Dr. E. H. Lewitt. Fifth edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 30*s*. net.]

Production Engineering for Higher National Certificate. II. Jig and Tool Design. By R. Dent. English Universities Press Limited, St. Paul's House, Warwick-square, London, E.C.4. [Price 18*s*. net.]

Practical Design of Simple Steel Structures. Vol. II. Girders, Columns, Trusses, Bridges, etc. By Dr. David S. Stewart. Third edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 25*s*. net.]

Principles of Electronics. By L. T. Agger. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 18*s*. net.]

Luft- und Gastafeln zur Berechnung von Gasturbinen und Verdichtern. By Dipl.-Ing. J. Kruschik. Springer-Verlag, Mölkerbastei 5, Vienna 1. [Price 19*s*. 6*d*.]

Iowa Institute of Hydraulic Research. Proceedings of the Fifth Hydraulic Conference, June 9-11, 1952. Edited by John S. McNown and M. C. Boyer. The University, Iowa City, Iowa, U.S.A.

Petroleum and Performance in Internal-Combustion Engineering. By E. M. Goodger. Butterworths Scientific Publications, 88, Kingsway, London, W.C.2. [Price 32*s*. 6*d*. net, postage 1*s*.]

The M.K.S. System of Units. A Guide for Electrical Engineers. By T. McGreevy. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 21*s*. net.]

Faster Than Thought. A Symposium on Digital Computing Machines. Edited by Dr. B. V. Bowden. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 35*s*. net.]

A Modern First Course in Engineering Science. By F. L. Poyser. University Tutorial Press Limited, Clifton House, Euston-road, London, N.W.1. [Price 7*s*. 6*d*.]

Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 20*th May*, 1953, *at Bradford (Forster Square) Station in the North Eastern Region British Railways.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s*. net.]

T.D.A. Statistical Year Book. 1952. Timber Development Association, 21, College Hill, London, E.C.4. [Price 2*s*. 6*d*.]